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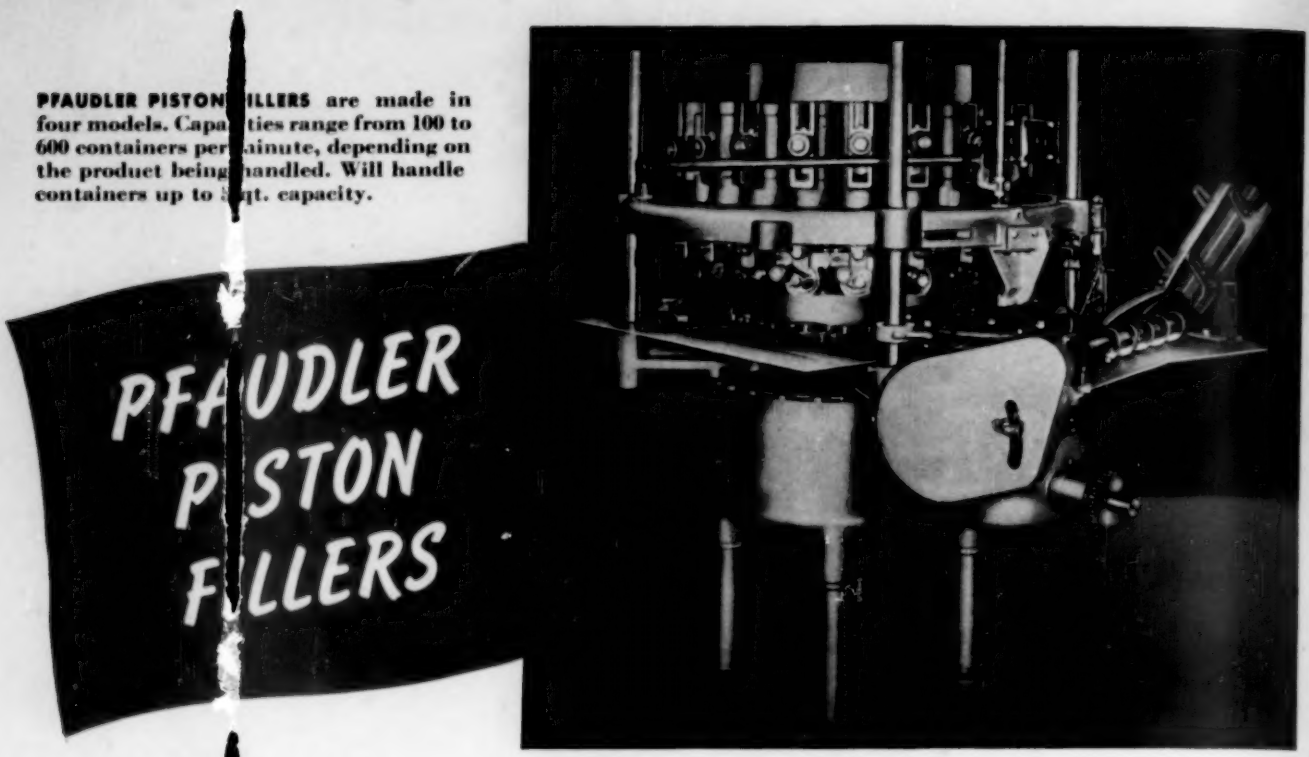

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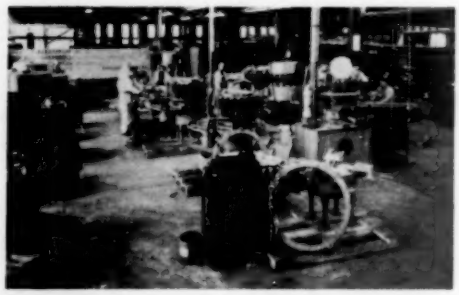

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Food Technology Curricula

This is the eighth of a series of articles which intend to elucidate the basic ideas which govern the curricula of our educational institutions in the field of food technology.

Food Technology at the Ohio State University

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(Manuscript received February 10, 1950)

Food technology instruction at The Ohio State University has followed rather closely the pattern set by the industry in the State. At first, the courses dealt almost exclusively with crop and animal production. As processed foods appeared on the market, courses were introduced in the subject matter departments which covered the techniques involved. Thus courses in dairy technology were taught in the Department of Dairy Husbandry as early as 1894 and a course in vegetable and fruit processing was taught in the Department of Horticulture as early as 1910. The first departmental recognition in the State started July 1, 1929, when the Department of Dairy Technology was created. This was followed in 1941 by a committee to encourage study and research in food technology and nutrition, which served to coordinate activities in the various schools and departments. This led up to the organization in 1945 of the Institute of Nutrition and Food Technology. The purposes of the Institute are to:

1. promote cooperative research in nutrition and food technology;
2. organize and integrate instructional programs to enable graduate and undergraduate students to receive training for specialized careers in nutrition and food technology;
3. mobilize the talents and facilities of The Ohio State University and The Ohio Agricultural Experiment Station in a coordinated program of education and research toward the broad objective of improving health through better nutrition and wiser use of technology in relation to foods, and
4. receive grants-in-aid for researches in nutrition and food technology, these grants to be administered for the Institute through the Research Foundation, the Development Fund, or the Experiment Station.

The Institute has coordinated the activities of many departments of the University and Experiment Station, so that instruction and research in food technology are part and parcel of more than twenty departments on the campus and at the Agricultural Experiment Station at Wooster.

The current Director of the Institute is a member of the faculty of the College of Medicine. The Research Committee of the Institute includes, in addition to the Director of the Institute, the Director of the Agricultural Experiment Station, the Dean of the Graduate School, the Director of the Research Foundation, professors from the following departments: Agricultural Biochemistry, Animal Husbandry, Bacteriology, Dairy Technology, Horticulture and Forestry, Home Economics, and Poultry Husbandry. The other committees likewise are chosen to secure the widest possible representation.

The committees on instruction have set up curricula in food technology and in nutrition. The former, food technology, is based upon the application of the principles of chemistry, mathematics, physics, bacteriology and engineering to the manufacture, processing, preservation and preparation for the table of agricultural products. It is designed to prepare students for positions in food industries, regulatory and control work, research and preparation for graduate work. The Bachelor of Science degree in Food Technology requires 206 hours for graduation in the case of men; 202 in the case of women who do not take 4 hours of military science.

Chemistry	29 hours
Agricultural Biochemistry	11 hours
Mathematics	15 hours
English	9 hours
Physics	15 hours
Bacteriology	11 hours
Dairy Technology	5 hours
Economics	9 hours
Home Economics	5 hours
Animal Husbandry	5 hours
Poultry Husbandry	3 hours
Horticulture	8 hours
Mil. Sci. and Phys. Ed.	16 hours
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In addition to the above, each student must elect at least 25 hours from three or more of the following departments or areas:

Business organization, Economics, English, Fine and Applied Arts, Foreign Languages, Geography, Geology, History, Journalism, Music, Philosophy, Photography, Physiology (human), Political Science, Psychology, Sociology, Speech. These courses are designed to broaden the students' fund of knowledge. Most advisors insist on the inclusion of Journalism and Speech.

The student is permitted to elect an additional 40 hours or more from the following technical fields:

Agricultural Biochemistry	25 hours
Agricultural Engineering	8 hours
Agronomy	10 hours
Animal Husbandry	23 hours
Bacteriology	9 hours
Chemical Engineering	12-22 hours
Chemistry	22 hours
Dairy Husbandry	10 hours
Dairy Technology	27 hours
Home Economics	27 hours
Horticulture	43 hours
Mathematics	10 hours
Poultry Husbandry	16 hours
Veterinary Anatomy	5 hours
Veterinary Physiology	9 hours

Though it is theoretically possible to elect courses from nearly all of the above areas the student usually elects most of his technical subjects in one or two of these areas. This permits greater specialization. For example, a student specializing in the processing of vegetables and fruits would take all of the courses dealing with processing in Horticulture. This would include the courses entitled: Principles of Food Preservation; Canning, Freezing and Dehydration; Pickling and Fermentation; Food Products Examination; Specialty Products (Horticulture) and Commercial Management and Practices with Horticultural Products. The laboratory work in all of these courses would be taken where pilot plant facilities are available for semicommercial processing. In addition, one or more courses in fruit and vegetable crop production are elected. Most positions in food technology in our area require considerable knowledge of production as related to quality control practices and grade standardization. Without this knowledge the student is severely handicapped.

A student electing to specialize in agricultural biochemistry would take more courses in chemistry and chemical engineering. Students in home economics include food preparation, food service, food preservation and experimental cookery in their curricula.

In all of these courses, regrdless of specialization, it is to be observed that foods and the efficient methods of handling foods to preserve their quality are stressed continually. This we believe is essential for the training of good technologists.

In addition to the above described courses in food technology and a similar one equally comprehensive in nutrition, the University offers a number of degrees for more restricted subject matter specialization. For example, the Department of Dairy Technology has its own curriculum; the Department of Horticulture offers a major in horticultural products. Practically all of the areas offer advanced work leading to the Master's or Doctor's degree in specific fields of specialization. It is here that the Institute of Nutrition and Food Technology is especially helpful by securing funds for fellowships and equipment for research.

The development of leadership in students is obtained in part by their participation in student clubs in each of the several areas such as in the Departments of Horticulture and Agricultural Chemistry and the School of Home Economics. Students arrange for speakers and thus obtain a direct contact with industry and the problems of industry. Many of the Ohio State students who are specializing in food technology are members of the Ohio Branch of the Institute of Food Technologists.

Storage Studies on Yeast-Fermented Dried Egg White [a, b]

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(Manuscript received August 8, 1950)

Large scale trials indicate that the removal of glucose from egg white by dry yeast pellets is commercially feasible. The nature of the organisms, their convenience of supply, and their speed of action are of particular importance to the industry. This study shows that with yeast fermentation a high grade albumen results and that undesirable microorganisms have little opportunity to reproduce. Excellent angel cakes can be made by using pan-dried yeast-fermented albumen. Another important purpose of this study has been to investigate the keeping qualities of yeast-fermented egg white stored at 22° C. (71° F.) and 40° C. (104° F.) for varying periods of time up to 18 weeks. The effects of fermenting, drying, and storing egg white on its suitability for making angel cake are reported.

The fermentation of raw egg white prior to drying has been adopted commercially as a necessary step in the production of a stable dried albumen. Various organisms might be used in producing the fermentation; however, yeast fermentation has proved more satisfactory than spontaneous fermentations or pure culture fermentations. Some of the important advantages of yeast fermentations are that it does not (1) contaminate the product, (2) introduce undesirable by-products, (3) produce an excess of acid, (4) cause a loss of mucin, or (5) give rise to objectionable odors or flavors. Also yeast is acceptable from a sanitary standpoint and produces a rapid fermentation which results in a high grade edible albumen with excellent whipping qualities.

Ayres and Stewart *(1)* reported on the use of yeast for the removal of glucose from egg albumen before drying. Large scale trials have indicated that this method is commercially feasible. Shortly after drying, the product showed all the properties of fresh egg white. Angel cakes made with it compared favorably in volume and texture with cakes made from fresh egg white. Information was needed on the performance of yeast-fermented egg white after storage; hence, the present study was undertaken.

In industry, a "spontaneous" fermentation of egg white is commonly used previous to drying; however, this method has several disadvantages. The reduced angel cake-making power of rehydrated "spontaneous" fermented albumen has limited its use. A dried albumen with the leavening power of fresh egg white and suitable for making high quality angel cakes would probably find wide application in the food industry. Specifically, this study is concerned with the cake-making properties of yeast-fermented dried albumen, after various periods of storage at 40° C. (104° F.) and 22° C. (71° F.).

METHODS AND MATERIALS

The fermentation procedure was similar in many respects to that described previously by Ayres and Stewart *(1)*. As in the

[a] Presented at the Tenth Annual Meeting of the IFT, Chicago, Illinois, May 23, 1950.

[b] Journal Paper No. *J-1817* of the Iowa Agricultural Experiment Station, Ames, Iowa. Project Nos. *970* and *1026*.

earlier studies, commercial dry yeast pellets were used to remove the sugar from the egg white. The speed of fermentation was shown to be dependent upon: (1) the size of inoculum, (2) an adequate supply of accessory food factors for supporting yeast metabolism in the presence of the inhibitory agents indigenous to egg white, (3) the temperature of incubation, and (4) the initial pH of the albumen. Also, with this method, the pH at the glucose-free stage can be kept at any pH within the range 6.4-7.2 simply by providing the proper ratio or by stirring to free the accumulating carbon dioxide. The resulting dried albumen has a pH over 8.5 and retains good angel cake-making properties.

In the present study the following fermentation procedure was used: Egg white was taken from the shell and the thick and thin white were blended. Commercial dry yeast pellets (0.3 percent) and yeast extract (0.1 percent) were mixed with a small amount of water and, after warming to 32° C. (90° F.), the blended albumen, which was adjusted to a pH below 8 by the addition of acid, was added and the mixture was allowed to ferment for one hour at 32° C. (90° F.). To this fermented albumen, yeast extract (0.05 percent) was added (on the basis of the succeeding fermentation which contained six parts of fresh albumen (pH<8.0) to one of yeast-fermented material). After thorough mixing, the second batch was fermented for two hours at 32° C. (90° F.); at this time the sample had most of the glucose removed. The entire batch was then used as an inoculum. In this case three parts of fresh albumen were incorporated with one part of the fermenting albumen. Yeast extract or acid were not added to the final fermenation in order to avoid excessive yeast metabolism. At the sugar-free stage which was determined by the 15 minute browning test *(2)*, the albumen was dried. This sugar-free stage occurred after approximately four more hours of fermentation.

Two hundred fifty ml. of egg white was then poured onto aluminum trays (16″ x 11½″ x 1″) to a depth of 1/16″. These trays were placed under a battery of infra-red heat lamps, care being taken to keep the temperature of the albumen below 40° C. (104° F.) until a "heavy skin" formed on the surface. The lights were then turned off and drying was completed with the aid of a fan moving air heated to about 27° C. (80° F.).

Three separate trials were made; one in the fall, the second in the winter, and the third in the spring. For each of these, 36 dozen three day old eggs from the College poultry farm were broken and separated, and the whites were blended to obtain a homogeneous sample. Blending was accomplished by using a Waring Blendor in which the speed was reduced by means of a variable voltage transformer set at 50 v. The egg white (920 ml.) was blended for 60 seconds during which time a 125 ml. Erlenmeyer flask was submerged about ½ inch in the liquid to prevent whipping air into the white. After blending, the egg white was a thin, uniform liquid and poured easily. Preliminary experiments showed that the blended egg white required a shorter beating time to reach the "soft peak" stage of the meringue and made angel cakes of higher volume than unblended material. Albumen blended for 60, 90, and 120 seconds at 50 v. showed slight differences in beating time and the volumes of the angel cakes were similar (see Table 1). Egg white blended for 240, 360, and 480 seconds at 50 v. required a longer beating time for the meringue to reach the "soft peak" stage. These results show the same trend as those of MacDonnell, Hanson, Silva, Lineweaver, and Feeney *(3)* who reported an increase in beating time of meringue with an increase in the blending time of egg white from 20 to 80 seconds at 60 v.

TABLE 1

Effect of Blending on the Whipping Properties of Egg White

Time of Blending	Beating Time of Meringue	Beating Rate of Meringue	Angel Cake Volume per 100 ml. of batter
(seconds)	*(seconds)*	*(ml./g./sec.)*	*(ml.)*
0	56.8	0.080	571
30	21.0	0.267	607
60	19.5	0.313	624
90	18.8	0.329	625
120	21.9	0.276	622
240	25.2	0.207	621
360	25.3	0.211	612
480	30.1	0.170	580

All of the blended egg white was mixed well and was then divided into three parts. One aliquot was frozen in lots of 260 ml. (sufficient for four angel cakes), a second part was dried, and the remaining third was fermented and then dried. After drying, 36 grams of the product were sealed with wax in small bottles and stored at 40° C. (104° F.) and 22° C. (71° F.). Samples were removed at the end of 1, 2, 3, 4, 5, 6, 8, 12, 16, and 18 weeks, at which time the color of the sample was noted and angel cakes were made.

The formula used for the angel cakes was as follows: fresh or rehydrated egg white, 61 g. (dried egg albumen 8.5 g.; distilled water 56.5 ml.); sugar, 62.5 g.; cake flour, 22.5 g.; cream of tartar, 0.9 g.; and salt 0.3 g. The temperature of the egg white was brought to 21° C. (70° F.) in a Hobart mixer bowl (Mixer Model K-4-B) and the beating was started at high speed (setting 10). The cream of tartar and salt were added immediately and 47 gm. of sugar were added in three equal portions at 10, 15, and 18-20 seconds. Beating was continued to the "soft peak" stage which is characterized by the appearance of the meringue, (that is, very small air bubbles, a dull white color, and the meringue peak caused by removing the beater from the foam forms a hook which turns down slightly). The flour-sugar mixture which consisted of 22.5 g. of cake flour and 15.5 g. sugar sifted together three times, was folded into the meringue in three equal portions using ten strokes of a wire whip for each addition.

The specific gravity of the meringue and batter was determined by weighing a portion of each in a container of known volume. A record was made of the beating time of the meringue. The specific volume of the meringue was calculated by dividing the foam volume (60 ml.) by the foam weight. The rate of beating was determined by dividing the specific volume by the total beating time; in other words, the rate of beating was measured in terms of increased specific volume of foam per second of beating[ml./g./sec., see Slosberg, Hanson, Stewart, and Lowe *(4)*].

One hundred ten grams of batter were weighed into a baking pan (2.75″ x 3.5″ x 5.5″) of known volume and baked at 174° C. (345° F.) for 25 minutes in a Despatch Rotary Oven (Model-150-R). After baking, the cakes were inverted, cooled and stored at 22° C. (71° F.) overnight. The cake volume was measured by the seed displacement method; the results are reported on the basis of 100 grams of batter.

Cakes were judged for quality by a carefully selected and trained panel. Triangle (odd sample) tests, numerical grading, and ranking were used to evaluate the cakes on the day following baking.

RESULTS AND DISCUSSION

General. Similar results were obtained in all three trials. Since the differences in the results were small, the data were pooled and averaged.

As expected, there were marked differences in the color stability of the dried albumens. After two weeks of storage at 40° C. (104° F.) a definite orange color was evident in the unfermented sample while the fermented albumen had not changed. The unfermented product was "burnt" orange at the end of four weeks and by six weeks was a deep brown. The fermented products showed no visible change in color even after five months of storage at 40° C. None of the products stored at 22° C. (71° F.) showed any change in color during the 16 weeks storage period. Samples stored for 10 weeks at 40° C. (104° F.) and 22° C. (71° F.) are shown in Figure 1.

Effect of Storage on Beating Rate. The average beating rates are shown in Figure 2. The decrease in beating rate of the meringue made with rehydrated unfermented egg white was most pronounced during the first two weeks of storage at 40° C. (104° F.). By that time

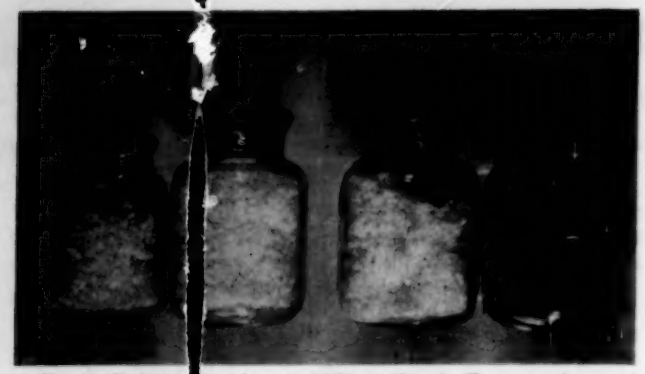

FIG. 1. Dried egg white stored 10 weeks. 1: Fermented, stored at 22° C. (71° F.); 2: Fermented, stored at 40° C. (104° F.); 3: Unfermented, stored at 71° F.; and 4: Unfermented, stored at 104° F.

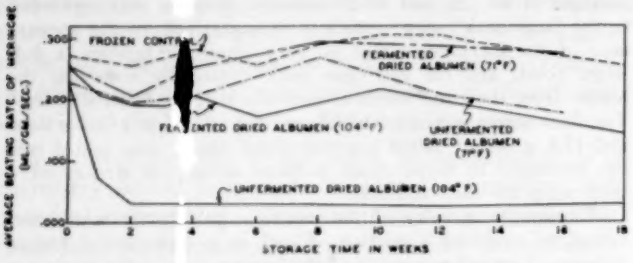

FIG. 2. Effect of storage at 40° C. (104° F.) and 22° C. (71° F.) on the beating rate of meringue for angel cakes made with yeast-fermented and with unfermented dried albumen.

there was a drop of 89 percent (from 0.235 to 0.026), whereas the beating rate for rehydrated fermented albumen meringue decreased only 25 percent (from 0.255 to 0.190). After 18 weeks of storage at 40° C. (104° F.) the beating time of the unfermented egg white increased from 24 to 240 seconds. The beating time for the rehydrated fermented albumen stored the same period of time and at the same temperature increased from 23 to 31 seconds. It may be seen that rehydrated fermented albumen had a much higher beating rate after 18 weeks of storage than the meringue made with rehydrated unfermented albumen had after one week's storage.

The samples stored at 22° C. (71° F.) did not show much change in performance after 10 weeks of storage. However, the unfermented dried egg white apparently was beginning to deteriorate at the end of 12 weeks as indicated by a decrease in beating rate of the meringue. The fermented sample had not changed even at the end of 16 weeks.

Effect of Storage on Angel Cake Volume. Cakes made from all samples of egg white before storage were similar in volume, texture, and appearance.

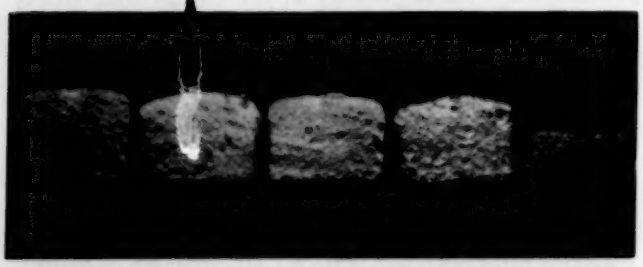

FIG. 3. Angel cakes made with samples of egg white stored 10 weeks. 1: Fermented, stored at 71° F.; 2: Fermented, stored at 104° F.; 3: Unfermented, stored at 71° F.; 4: Unfermented, stored at 104° F.; and 5: Frozen control.

After only two weeks of storage at 40° C. (104° F.), cakes made with the rehydrated unfermented albumen were of poor quality. Certainly after four weeks of storage there was no question as to their being undesirable. The data for the cakes shown in Figure 3 are as follows:

Cake No.	Treatment	Storage Condition		Volume of Angel Cake, ml. per 100 ml. batter
		Temp.	Weeks	
5	Frozen (—30° F.)	—10° F.	10	628
1	Fermented, dried	71° F.	10	602
2	Fermented, dried	104° F.	10	572
3	Unfermented, dried	71° F.	10	592
4	Unfermented, dried	104° F.	10	277

Figure 4 shows the relationship between cake volumes and storage time. As may be seen, the volume of the cakes made with the rehydrated fermented egg white stored for two weeks at 40° C. (104° F.) were 5 percent (from 614 ml. to 586 ml.) less than before storage as compared with a 25 percent (from 618 ml. to 462 ml.) decrease in volume for the unfermented sample. Following this initial 5 percent loss in volume, cakes made from the rehydrated fermented albumen

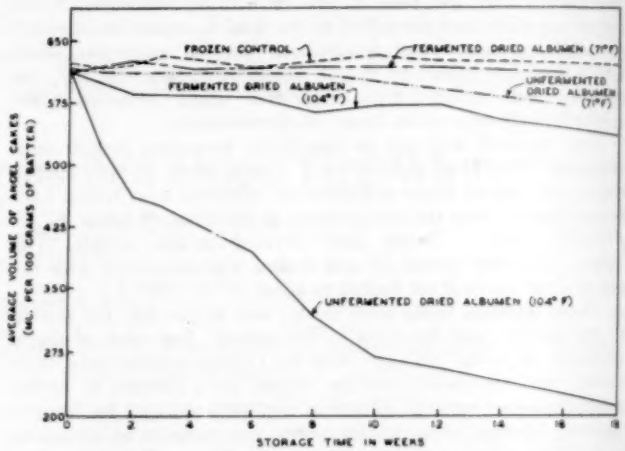

FIG. 4. Effect of storage at 40° C. (104° F.) and 22° C. (71° F.) on the volume of angel cakes made with yeast-fermented and with unfermented albumen.

showed no further change until the 12th week. By this time the cake volume was 10 percent (from 614 ml. to 555 ml.) less than before storage.

Results of the storage trials at 22° C. (71° F.) are most interesting. The changes in properties occurred much more slowly than at 40° C. (104° F.). Cake volumes of both dried samples remained similar to the frozen controls until the 12th week of storage. By this time there was a decrease of only 3 percent (from 618 ml. to 590 ml.) in the cake volume of the rehydrated unfermented egg white; there was no change in the performance of the fermented sample. After 16 weeks of storage at 22° C. (71° F.), the fermented dried egg white did not show any detectable changes, whereas the unfermented sample showed a decrease in volume of 7 percent (from 618 ml. to 573 ml.).

Effect of Storage on Flavor. The rehydrated fermented egg white did not have an objectionable "off" odor. It did have a faint yeasty odor and the angel cakes made with it smelled slightly "bready" during baking. An analysis of variance of the flavor scores of a panel of

8 judges showed a highly significant difference, at the 1 percent level, between the flavor of cakes made with fermented albumen and those made with frozen egg white. The angel cakes had a peculiar "after-taste." Not all persons tested for the judging panel were able to detect it. Of a group of 30 men and women tested, 4 women and 6 men were unable to distinguish between unflavored (no vanilla in formula) angel cakes made with rehydrated fermented albumen and frozen egg white. When the standard amount of vanilla (0.5 ml.) was added to the cakes, all judges found it more difficult to pick out the cakes made with the fermented sample.

Analysis of the scores did not indicate any change in flavor of the angel cakes made with rehydrated fermented egg white after storage at either 40° C. (104° F.) or 22° C. (71° F.) for any of the periods used.

SUMMARY AND CONCLUSIONS

1. Dried, yeast-fermented egg white produced satisfactory angel cakes immediately after drying. Yeast-fermented egg white is soluble in water, rehydrates readily, and can be used to make high quality angel cakes. This egg white does not have an objectionable "off odor" and retains all the properties of fresh albumen, particularly whipping properties. Further work is being done on the flavor of this product.

2. After 16 weeks of storage at 22° C. (71° F.) there were no detectable changes in color and angel-cake making properties of yeast-fermented dried egg white. Storage at 40° C. (104° F.) caused some deterioration in this product. For example, there was a decrease of 5 percent in the volume of angel cakes made from a product stored at 40° C. for two weeks. After this initial loss, the material was quite stable until after 12 weeks of storage by which time there was a slight additional decrease of 5 percent.

3. The functional properties of unfermented dried egg white deteriorated rapidly at 40° C. (104° F.). A decrease of 26 percent in angel cake volume was noted after two weeks of storage. Angel cakes made with this product were definitely not satisfactory after 4 weeks of storage at 40° C. (104° F.). The solubility had decreased so much that it was impossible to rehydrate all of the albumen. When stored at 22° C. (71° F.) for 16 weeks, the product gave cakes showing 7 percent less volume than the unstored product.

Acknowledgment

The authors wish to express their appreciation to Janiece Foth who assisted in this study.

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Quality Evaluation of Fresh, Frozen, and Canned Yellow Sweet Corn[a]

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(Manuscript received May 29, 1950)

The quality of processed fruit and vegetable products is dependent primarily upon two factors: (1) the inherent characteristics of the edible portion, and (2) the external factors, which include handling methods and factory procedures. This paper summarizes three years of work on the quality evaluation of factors that are inherent in whole grain fresh, frozen, and canned yellow sweet corn. The objectives were two fold: (1) the establishment of quick objective measurements of quality for fresh, frozen, and canned yellow sweet corn, and (2) to show the relationship of the quality of fresh (raw) corn to its processed products (canned and frozen).

Culpepper and Magoon *(3, 4, 12)* in 1926, 1927, and 1928 have reported on quantitative chemical studies of factors determining quality in sweet corn. They listed the following four factors which "are preeminent in determining the quality of the canned product: (a) the degree of tenderness or toughness of the pericarp, (b) the nature of the polysaccharides present and the ratio of water soluble to total polysaccharides, (c) the sugar content and (d) the compactness with which the polysaccharides are laid down in the endosperm and possibly the cellular structure of the endosperm itself." As reported in their papers, these methods are rather tedious quantitative chemical measurements. However, in recent years several quick objective methods have been described which may be utilized to approximate measures of these chemical constituents. Some of the more important quick objective measurements of quality are discussed below.

Kertesz *(8)* in 1934 developed the present alcohol insoluble solids (AIS) method for determining maturity of peas. Jenkins *(6)* in the same year applied this method to sweet corn and found that the AIS determination would indicate the maturity of sweet corn. He proposed a maximum of 20.5 percent AIS for Grade A, 23.0 percent for Grade B and over 23 percent for Grade C whole kernel canned corn. In 1936 Jenkins and Sayre *(7)* found that the percent total solids and percent AIS may serve equally well as indices of maturity of canned whole kernel sweet corn. They further reported that the maturity and tenderness were directly proportional to scores assigned for flavor on the same samples. On April 12, 1950 the Food and Drug Ad-

[a] Presented at the Tenth Annual Meeting of the IFT, Chicago, Illinois, May 24, 1950.

ministration *(1)* proposed a maximum tolerance of 27 percent AIS for canned whole kernel sweet corn.

Sayre and Morris *(14)* in 1932 developed a method of expressing the sap from sweet corn which was used in evaluating its quality. Later Kramer and Smith *(10)* adopted essentially this principle and developed a simplified hydraulic press, the Succulometer. They state "it is equally accurate to a reliable moisture test on the raw product and the AIS content on the canned product, but is simple to operate and results may be obtained in a few minutes."

Scott, Belkengren, and Ritchell *(15)* described a rapid quality test on raw corn based on the refractive index of the sample. They obtained a correlation coefficient of 0.89 between the percent moisture, as determined by Brown-Duvel method, and the refractive index.

Parks *(13)* in 1944 obtained patents on a method for determining the moisture content in grains using excess calcium carbide to react with the moisture content of the sample. A similar technique was reported by Western Regional Research Laboratory *(17)* in March, 1950.

PROCEDURES

During the last three years several yellow sweet corn varieties (46 in 1947, 34 in 1949, and 13 in 1949) were grown according to acceptable commercial practices in the Horticultural Gardens. In 1947, each variety was harvested as close to optimum maturity as possible. This work was for observation and elimination of varieties not suitable for processing. In 1948, three harvests were made: pre-optimum (young), optimum, and post-optimum (mature) *(11)*. In 1949, four harvests were made: immature (very young), pre-optimum (young), optimum, and post-optimum (mature). The maturity of the corn in the field was determined by the number of days from silking, the thumbnail test, and by the accumulated "growth degree day" units. The corn was harvested in the morning and immediately delivered to the processing laboratory. It was prepared for processing and then processed by canning and freezing according to acceptable commercial practices.

Data taken on the raw produce consisted of succulence (Succulometer values), percent soluble solids (refractive index of expressed juice from succulometer determined with a Spencer refractometer), and the percent AIS. After a storage period of 6 months, the samples were opened and graded according to the USDA-PMA Standards of Quality for Whole Kernel Canned Sweet Corn by a panel of six judges. Color, tenderness, and flavor were scored by this panel; while maturity was determined by the following objective methods for both the canned and frozen corn: Percent soluble solids (determined on extracted liquid from Succulometer with Spencer refractometer), succulence by Succulometer values, percent AIS, and percent pericarp. The pericarp content was determined by macerating a 25-g. sample with 200 ml. of water in a Waring Blendor for exactly three minutes. The slurry was then washed on a previously weighed 30-mesh monel screen. This was then dried in an electric oven at 100° C. (212° F.) for two hours. The sample and screen were then cooled in a desiccator, reweighed, and the percent pericarp was calculated by the difference in weight multiplied by four. An identical method for pericarp content was recently reported by Kramer, Guyer, and Ide *(9)*.

The 1949 data was used for the calculations of correlation coefficients according to the method of Snedecor *(16)*.

DISCUSSION

Table 1 gives the correlation coefficients for the different factors studied in this work. With the exception of flavor vs. AIS content and percent soluble solids vs. AIS on the frozen product only, all of these correlations are significant at the 1 percent level; however, for prediction purposes the correlation coefficient should be above 0.70. On the raw product the "growth degree days "vs. AIS gives a correlation of 0.92. Figures 1 and 2 show graphically this relationship of AIS content to "growth degree days." Under the conditions that prevailed during the 1949 season, most varieties of sweet corn stood in the field until approximately 2260 "growth degree days" had accumulated before they were graded over-mature. Golden Cross Bantam and Ioana were the exceptions since they matured with approximately 2180 "growth degree days." These figures are not in-

TABLE 1

Correlations of Objective and Subjective Measures of Quality for 13 Varieties of Raw, Frozen, and Canned Yellow Sweet Corn Hybrids

Condition	Characteristics Correlated	Correlations ("r" values)
Raw	Growth Degree Days vs. % Cut off	+0.684**[b]
Raw	Growth Degree Days vs. Succulometer	−0.646**
Raw	Growth Degree Days vs. % AIS	+0.916**
Raw	Growth Degree Days vs. % Soluble Solids	+0.882**
Raw	Growing Days vs. % Cut Off	+0.687**
Raw	Growing Days vs. Succulometer	−0.617**
Raw	Growing Days vs. % AIS	+0.911**
Raw	Growing Days vs. % Soluble Solids	+0.868**
Raw	% AIS vs. % Soluble Solids	+0.896**
Raw	% AIS vs. Succulometer	−0.711**
Raw—canned	Succulometer vs. Succulometer	+0.594**
Raw—frozen	Succulometer vs. Succulometer	+0.835**
Raw—canned	% AIS vs. % AIS	+0.936**
Raw—frozen	% AIS vs. % AIS	+0.899**
Raw—canned	% Soluble Solids vs. % Soluble Solids	+0.740**
Raw—frozen	% Soluble Solids vs. % Soluble Solids	+0.476**
Canned	Tenderness vs. % Pericarp	−0.892**
Canned	% AIS vs. Tenderness	−0.776**
Canned	% AIS vs. % Soluble Solids	+0.725**
Canned	% AIS vs. Succulometer	−0.828**
Canned	% AIS vs. % Pericarp	+0.798**
Canned	% AIS vs. Flavor	−0.145
Canned	Succulence vs. % Moisture Content	+0.861**
Canned	% AIS vs. % Moisture Content	−0.915**
Frozen	Tenderness vs. % Pericarp	−0.537**
Frozen	% AIS vs. Tenderness	−0.702**
Frozen	% AIS vs. % Soluble Solids	+0.360*
Frozen	% AIS vs. Succulometer	+0.745**
Frozen	% AIS vs. % Pericarp	+0.579**
Frozen	% AIS vs. Flavor	−0.109
Frozen	Succulence vs. % Moisture Content	+0.765**
Frozen	% AIS vs. % Moisture Content	−0.787**

[b] The sign * indicates significance at the 5% level and ** shows significance at the 1% level.

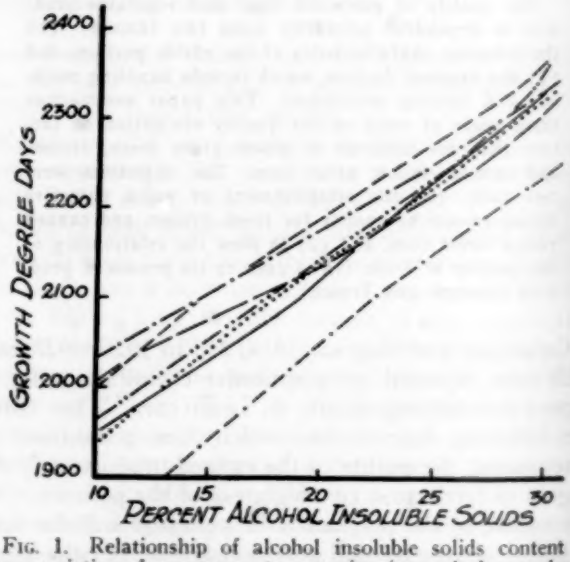

FIG. 1. Relationship of alcohol insoluble solids content of seven varieties of sweet corn to maturity (growth degree days) 1949. Varieties are: ———, Tendermost; — — Aristogold Bantam; — · —, Tendergood; — — · — · — , Ioana; — · · — Aristogold Bantam Ev.; — — — —, Flagship; and · · · · · · , Illinois Golden No. 10.

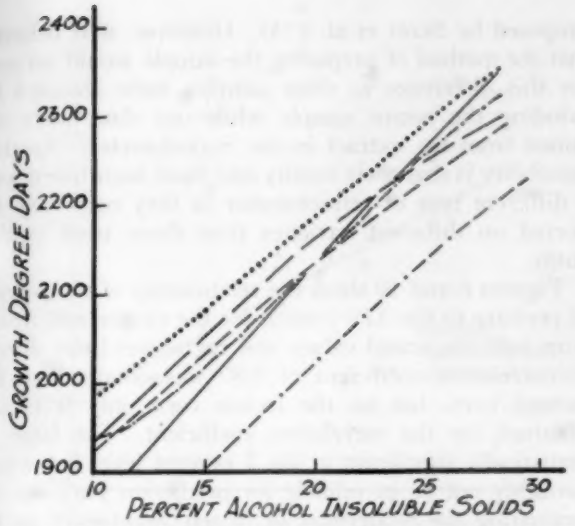

FIG. 2. Relationship of alcohol insoluble solids content of six varieties of sweet corn to maturity (growth degree days) 1949. Varieties are: ——— Victory Golden; — — Golden Security; — · —, Iochief; — — · —, Golden Cross Bantam; — — — —, O. T.O.; and · · · · · · , Big Lincoln.

tended to establish accumulated "growth degree days," but rather to show that the AIS content is an excellent measure of the maturity of sweet corn. Growing days could be substituted for growth degree units in 1949 since there was a correlation coefficient of 0.91 between growing days and AIS content.

Figure 3 and Figure 4 show the relationship of the AIS content of the fresh or raw corn to the AIS content of the canned and frozen sweet corn, respectively. The regression lines are also plotted to show the calculated values against the actual values obtained. It should be pointed out, however, that the AIS content of the frozen sweet corn is approximately 2 percent lower than that of the fresh corn at the most mature stage. However, this relationship is reversed at the immature stage where the AIS of the frozen corn is about 3 percent higher than that of the fresh corn. The canned corn is

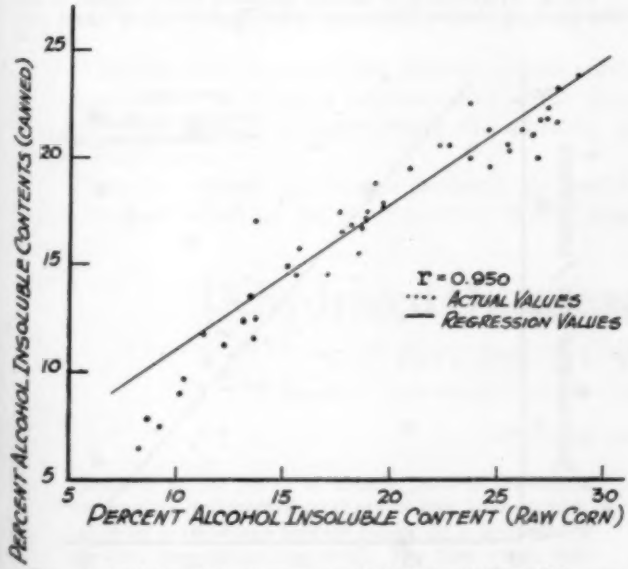

FIG. 3. Relationship of percent alcohol insoluble solids content of fresh sweet corn to percent alcohol insoluble solids of canned sweet corn.

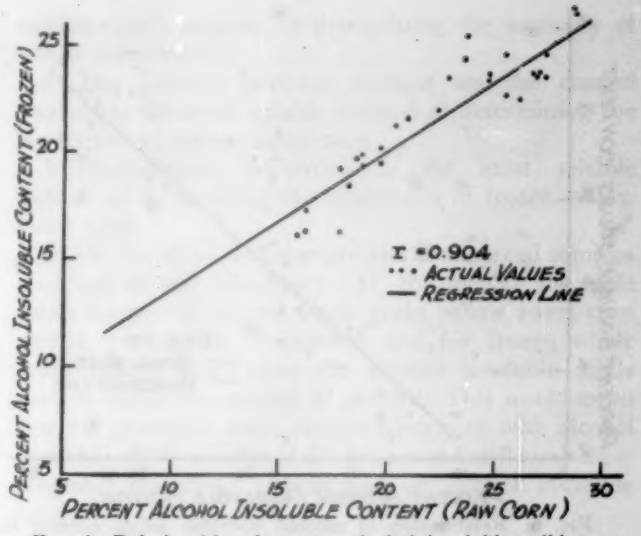

FIG. 4. Relationship of percent alcohol insoluble solids content of fresh sweet corn to percent alcohol insoluble solids of frozen sweet corn.

approximately 4 percent lower than the fresh corn, but is of equal value at the immature stage. The correlation coefficient between the fresh and canned corn for AIS is 0.94 and between the fresh and frozen corn it is 0.90. The probable reason for the lower AIS values in both the frozen and canned product at the mature stage is that during the process (blanching for the frozen product and retorting at 121° C. (250° F.) for the canned product) conversion of insoluble solids to soluble solids takes place. With this in mind, the data indicates that a processor could use fresh corn with the AIS

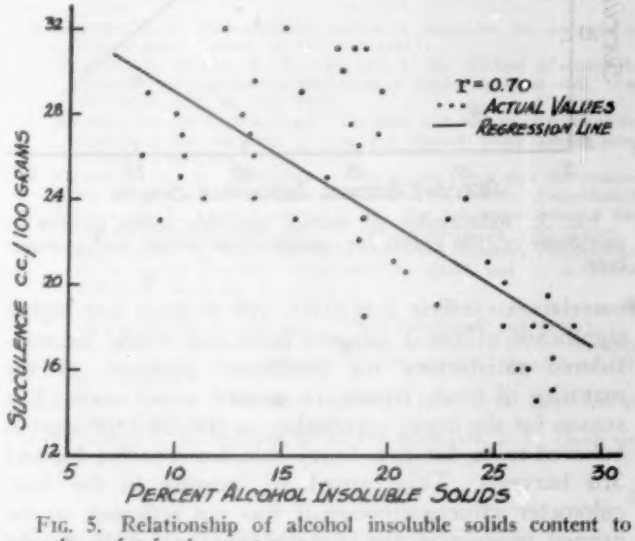

FIG. 5. Relationship of alcohol insoluble solids content to succulence for fresh sweet corn.

content about 27 percent and still be within the tolerance as established by the Food and Drug Administration.

Figures 5, 7, and 9 show the relationship of succulence to AIS content for fresh, canned, and frozen sweet corn, respectively. The charts show the actual values and the regression lines for each product. A correlation coefficient of 0.83 and on the canned product was the highest obtained with the frozen product having a correlation coefficient of 0.75 and the fresh product a

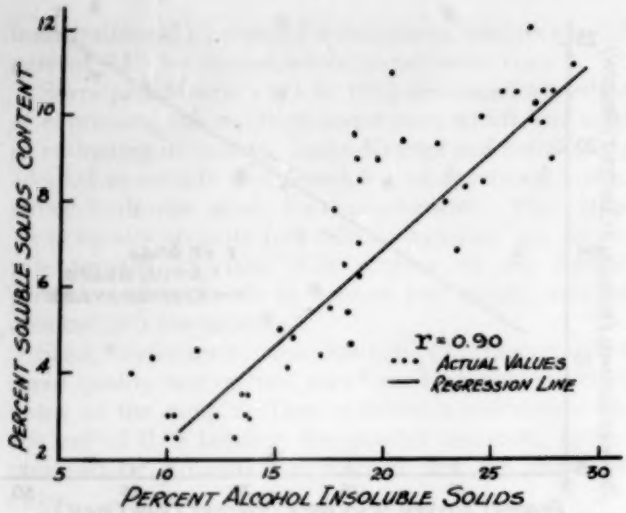

FIG. 6. Relationship of alcohol insoluble solids content to soluble solids content for fresh sweet corn.

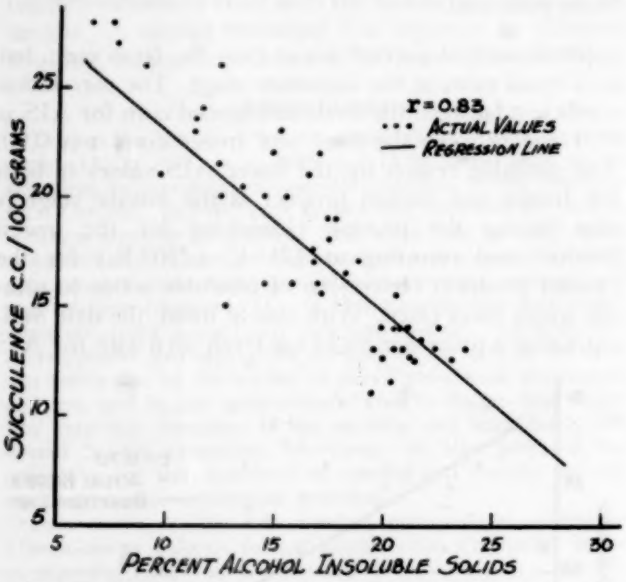

FIG. 7. Relationship of alcohol insoluble solids content to succulence cc./100 grams for canned whole kernel wellow sweet corn.

correlation coefficient of 0.70. All of these are highly significant at the 1 percent level and would be considered satisfactory for prediction purposes of the maturity of fresh, frozen, or canned sweet corn. The reason for the lower correlation on the fresh product is believed to be due to a heavy rain between the 1st and 3rd harvests. This caused an increase in the Succulometer values, although it was not reflected on the canned product to the same extent as on the frozen product. Furthermore, it should be emphasized that these values are for all varieties studied and they tend to balance out abnormalities between varieties.

Figure 6 demonstrates the relationship of the percent of soluble solids to the percent of AIS with both the actual values and the regression line shown. A correlation coefficient of 0.90 was obtained. This would indicate that the percent of soluble solids as determined by the Spencer refractometer is an excellent method of predicting the maturity of sweet corn. These values obtained in this study are considerably lower than those proposed by Scott et al. *(15)*. However, it is believed that the method of preparing the sample would account for this difference as their samples were obtained by grinding the entire sample while our data were obtained from the extract in the Succulometer. Another possibility is that their results may have been taken with a different type of refractometer or they may have reported on different varieties than those used in this study.

Figures 8 and 10 show the relationship of the percent of pericarp to the AIS content for the canned and frozen corn with the actual values and regression lines shown. A correlation coefficient of 0.80 was obtained on the canned corn, but on the frozen corn only 0.58 was obtained for the correlation coefficient. The latter is statistically significant at the 1 percent level but would probably not be as reliable for prediction purposes for evaluating the tenderness of frozen sweet corn as the percent of pericarp is for the canned sweet corn. This relationship holds true when considering the organoleptic evaluation versus the percent of pericarp as indi-

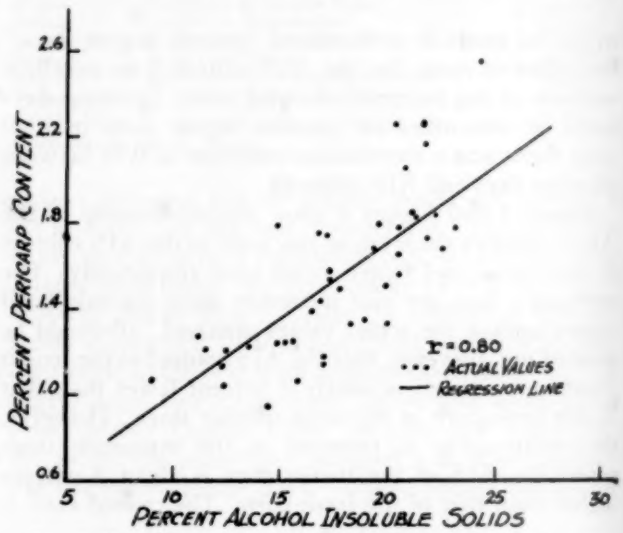

FIG. 8. Relationship of alcohol insoluble solids content to percent pericarp content for canned whole kernel yellow sweet corn.

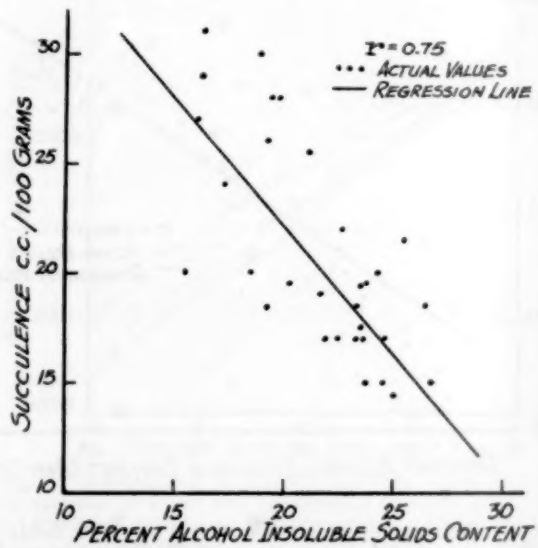

FIG. 9. Relationship of alcohol insoluble solids content to succulence for frozen whole kernel yellow sweet corn.

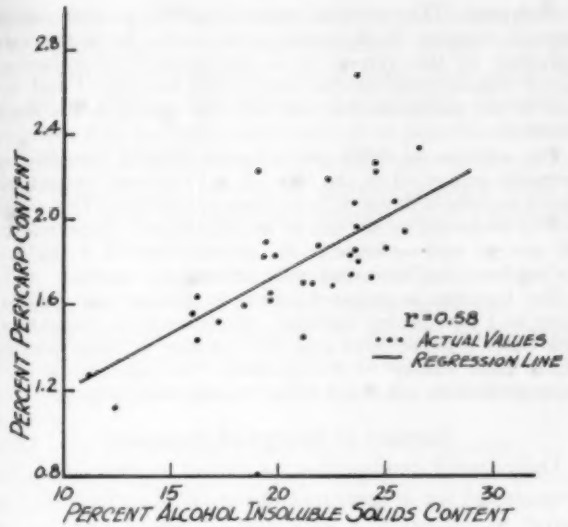

FIG. 10. Relationship of alcohol insoluble solids content to percent pericarp content for frozen whole kernel yellow sweet corn.

cated in Table 1. By organoleptic evaluation versus percent of pericarp on the canned product a correlation correlation coefficient of 0.89 was obtained while in the frozen product a correlation coefficient of only 0.54 was obtained. However, organoleptic evaluation of tenderness versus AIS content on the frozen product gave a correlation coefficient of 0.70 thus indicating that the tenderness of frozen sweet corn is associated with the alcohol insoluble content rather than with the pericarp content.

CONCLUSIONS

1. Of the objective methods used in this study and as indicated by the correlation coefficients, the alcohol insoluble solids content (AIS) is the most reliable method of determining the maturity of fresh, frozen, and canned yellow sweet corn. The alcohol insoluble solids content of the canned sweet corn is approximately 4 percent lower than in the comparable fresh corn while that of the frozen product is approximately 2 percent lower.

2. With the fresh product, the percent soluble solids as determined by a Spencer refractometer is the most reliable quick method of determining the maturity of yellow sweet corn.

3. With the canned and frozen products, the succulence, as determined by the Succulometer, is the most reliable quick method of determining the maturity of yellow sweet corn.

4. The percent pericarp content on the canned product is the most reliable method of determining the tenderness of yellow sweet corn.

5. Organoleptic evaluation is the most reliable method of determining the tenderness of frozen yellow sweet corn.

6. On the basis of this study and commercial samples analyzed in our laboratory *(5)*, the alcohol insoluble solids content of canned whole grain yellow sweet corn should not exceed 25 percent, and for frozen whole grain yellow sweet corn the alcohol insoluble solids content should not exceed 27 percent. This would mean that the processor could receive fresh corn with alcohol insoluble solids content of 29 percent and still meet these proposed maximum percentages of alcohol insoluble solids.

Acknowledgments

The writers wish to acknowledge the helpful suggestions and criticisms of Dr. H. D. Brown and the kind assistance of Miss Dorothy Culler, Mr. Noel Cooper, and Mr. Eugene Carroll.

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Dehydrated Orangeade by a Two-Stage Process

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Removal of the water of orange juice to produce a high quality granulated orangeade has been accomplished by a two-stage process following a preliminary treatment for viscosity control. The first stage consists of vacuum concentration to high solids in a vacuum pan whereby 97 percent of the water is economically evaporated, the second removing the balance of the water by vacuum-shelf dehydration after adding granulated sugar to form a solid magma.

Efforts to obtain orange juice in a concentrated form with maximum stability in respect to flavor and ascorbic acid retention have led to extensive studies of various

dry forms of the juice. The transportation and storage advantages of an acceptable dried juice are of particular interest to the food agencies of the armed forces. Spray-dried corn syrup-citrus juice combinations have been manufactured for many years and one, the lemon, was extensively used as a component of the K ration lemonade powder of the U. S. Quartermaster Corps during World War II.

The heat-sensitive nature of orange juice has made it a difficult liquid to dry with a satisfactory flavor retention. The use of the so-called "freeze-dry" method has been tried with some degree of success but this is of necessity a slow, expensive process requiring large capital investment. The reader is referred to the simultaneously published articles of Schroeder and Cotton, and Schwarz and Penn for specific information and bibliographies *(3, 4)* also to the earlier article by Flosdorf *(1)*. The hygroscopic nature of the pure dried orange juice makes it difficult to dry as well as to handle and store satisfactorily. Caking of the powdered, flaked, or granulated product during any extended storage is apt to occur, making subsequent dispersion very difficult.

Contrary to common belief, deterioration of flavor and lowering of vitamin content may continue in the dry product, especially at elevated temperatures. In general, however, dry juice is considered more stable than the liquid product.

The following method, as developed in this laboratory, has been found to give a product with satisfactory flavor and general stability. The material is much less hygroscopic than most dried orange juices and the production process is much more economical.

METHODS

Preparation of Dehydrated Orangeade. Extraction of the Valencia orange juice may be accomplished by mechanical burring or any other method which tends to keep the pectin content at a minimum. The juice should be put through a fine screen (40 mesh) to remove the larger pulp particles. This freshly extracted juice is buffered with a mixture of sodium carbonate (15 percent) and calcium carbonate (85 percent) to a pH of 4.0, and then flash pasteurized at 75° C. (167° F.) with a one minute holding time. The water-heated plate pasteurizer used in this work raised the juice to the required temperature in three seconds. After holding, cooling was instantaneously effected by flashing into a vacuum pan.

The juice is then concentrated at about 43° C. (110° F.) in the vacuum pan to 80-85° Brix. Then the concentrated juice is mixed with 2 to 2.5 times its weight of dry granulated sucrose forming a moist granular mass. The exact proportion of concentrate to sugar is dependent on the solids content of the former. The moisture content of the mixture must be low enough to prevent the mass from melting down during subsequent processing.

The addition of calcium carbonate at this point has been found to aid drying. A ratio of 1:8 for calcium carbonate to anhydrous citric acid in the juice is a satisfactory amount for this purpose.

Sufficient ascorbic acid may be added to this mixture to provide a total of 0.05 percent in the finished beverage. This is equivalent to 0.35-0.40 percent in the dry product.

After thorough mixing, the material is spread in shallow pans and dried in a vacuum shelf drier at 50° C. (122° F.) and about 20 mm. pressure. The moisture content in the finished product should be around 0.5 percent. Low moisture content means increased stability of the product during storage.

The dried material is now ground to about 15 mesh, and sufficient anhydrous citric acid of comparable fineness is added to give an anhydrous citric acid content of 3.5-4.0 percent or as preferred. This product, comprising 99.5 percent nutritive material, contains 25-30 percent juice solids, being the weight equivalent in this respect of a concentrated juice having a 2-2.5:1 volume concentration ratio. This has been found to be close to the maximum that may be dried easily in the manner described.

The addition of 0.006 percent good quality, five-fold concentrated orange oil in the form of a 10 percent extract gives a good acceptable flavor with satisfactory stability. This stability may be increased by the use of an antioxidant. Experimentally 0.01 percent hydroquinone in the extract (or 0.06 p.p.m. in the dry product) has been used with satisfactory results.

The beverage is prepared merely by adding 6 or 7 parts of water to 1 part of dry material. No difficulty in reconstitution with water is experienced even after storage or under conditions which cause caking of the product. The appearance of the beverage in both color and cloud is exceptionally good.

Stability of Dehydrated Orangeade

Dehydrated orangeades, prepared as described, have been stored for several months at 37° C. (98.6° F.) and found to maintain a satisfactory flavor and ascorbic acid (vitamin C) content. In Figure 1, the ascorbic acid retention of two dehydrated orangeades during storage at 37° C. (98.6° F.) is shown. One of these samples was prepared with added ascorbic acid while the other contains only the natural ascorbic acid of the orange juice. Ascorbic acid determinations were made by the iodine titration method *(5)*.

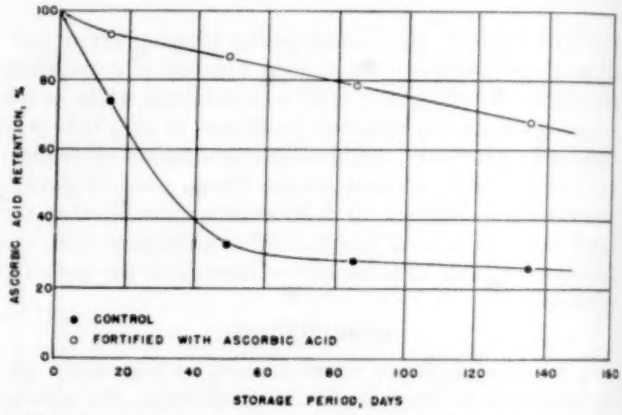

FIG. 1. Ascorbic acid retention in dehydrated orangeades stored at 37° C.

The consistent loss of reducing power in the stored product with no subsequent increase indicates that there was not appreciable reductone interference as has been reported for some stored substances *(2)*. The slower rate of loss in the fortified sample substantiates this view.

The increased stability of the sample containing added ascorbic acid is striking evidence of the effectiveness of this material as an antioxidant. The samples prepared with ascorbic acid showed an almost complete absence of darkening during storage for 5 months at 37° C. (98.6° F.) with air in the headspace of the container. Packaging in vacuum increased ascorbic acid retention and is also recommended to prevent deterioration of the flavoring oil.

Theory of Method

If orange juice is to be concentrated even in an ordinary vacuum pan to 80-85° Brix, it is necessary that the viscosity of the juice be kept at a minimum by suit-

able processing. This is especially true if concentration at low temperature is contemplated. High pH and limited enzyme action have been found to promote the desired condition. By the use of a mixture of calcium carbonate and sodium carbonate, it is possible to reach the desired pH without precipitating too much calcium citrate and at the same time provide enough ions to buffer the juice during concentration, thus preventing too great a drop in pH.

The limited pasteurization previously described is adequate for destroying most microorganisms which might be present. However, it allows some pectic enzyme activity to remain which, catalyzed by the calcium ions, has the desired effect on the consistency of the juice.

The dry granulated sugar serves mechanically as a surface extender which greatly accelerates the drying. Calcium carbonate added at this step is also helpful in the drying procedure.

Besides acting as an excellent antioxidant, the added ascorbic acid fortifies the beverage, making it equivalent to natural strength juice in this respect. A retention of 98.8 percent has been found for ascorbic acid during the entire preparation of a dehydrated orangeade.

SUMMARY

A fortified dehydrated orangeade which has excellent stability has been made in an economical manner. Upon the addition of water, a beverage having good flavor and equivalent in ascorbic acid content to natural strength orange juice can be obtained.

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Role of Glucose in the Storage Deterioration of Whole Egg Powder. II. A Browning Reaction Involving Glucose and Cephalin in Dried Whole Eggs[a]

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Evidence is presented for an amine-aldehyde reaction involving glucose and the phospholipid cephalin, which occurs during the storage of dried whole eggs. The removal of glucose before drying eliminates or greatly retards changes normally occurring in the phospholipid fraction during storage. These include loss in amino groups, browning, and development of fluorescence and ultraviolet absorption.

The type of nonenzymatic browning which results from the interaction of aldehydic compounds with those containing amino groups has received a great deal of attention in recent years, primarily because of its occurrence in foodstuffs *(1, 18, 19)*. While Maillard's early observations were confined to the browning which resulted from interaction of reducing sugars and amino acids heated together in concentrated aqueous solution *(20)*, more recent reports have described reactions between reducing sugars and proteins *(17, 22, 24, 27)*, low-molecular-weight aldehydes and proteins *(11, 23)*, furan derivatives and amino acids *(6, 31)*, simple amines and low-molecular-weight aldehydes *(3, 9)*, and even acetaldehyde and ammonia *(26)*. These systems involve reactions between compounds contained entirely in an aqueous phase. It is the purpose of this paper to present the evidence for an amine-aldehyde reaction involving a phospholipid, cephalin, contained in egg fat, and the reducing sugar, glucose. Egg cephalin appears to be entirely phosphatidyl ethanolamine *(5)*.

Glucose has been shown to be the only reducing sugar present in the free state in measurable quantities in eggs *(13, 25)*. Its interaction with the proteins of the white and yolk has been demonstrated both with model systems *(22, 24)* and during the storage of dried egg powders *(2, 16, 29)*. These reactions are characterized by visible browning, loss in protein solubility, development of water- or salt-soluble fluorescing substances, and loss in measurable amino groups. Methods for measuring these changes proved useful during World War II as empirical quality control tests for whole egg powder *(30)*. However, changes in these characteristics did not appear to correlate well with off-flavor development during the storage of dried whole eggs, particularly for low-moisture powders *(4)*, and the lipid constituents were therefore examined as the site of the flavor changes.

During an investigation of the contribution of phospholipids to the acidity of the ether extract of egg powders *(14)*, one of the authors became interested in the fact that the brown pigment and off-odors present in the egg fat isolated from stored dried whole egg powder resided almost entirely in the phospholipid fraction of the fat. Edwards and Dutton *(7, 9)* fractionated

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the "browned" phospholipid obtained from whole egg powder stored for 9 months at 38° C. (100° F.) into crude cephalin and lecithin, and found that the pigment accompanied the cephalin fraction. Cephalin and lecithin prepared from fresh egg are nearly colorless or pale yellow substances. Upon saponification of the "browned" cephalin, followed by ether extraction from acidic aqueous solution, a large part of the brown pigment was found to remain in the aqueous phase. This led these workers to suspect that the browning reaction involved in the deterioration of the phospholipid constituents in dried eggs was not restricted to the usual auto-oxidation reactions of aging lecithin. They performed experiments which strongly suggested that the browning was due to the interaction of the amino group of cephalin with an unknown aldehyde. Their evidence was based upon the following experiments:

(a) Cephalin, freshly prepared from high-quality egg, when allowed to react at room temperature with acetaldehyde, rapidly turned brown. Ethanolamine, the amino-containing moiety of cephalin, reacted similarly. Neither lecithin nor its nitrogen-containing moiety, choline, reacted appreciably under the same conditions.

(b) Ether solutions of cephalin, freshly prepared from high-quality eggs, exhibited negligible absorption in the ultraviolet range. Both cephalin prepared from stored egg powders and the reaction product of cephalin with acetaldehyde showed greatly increased absorption in the ultraviolet (measured in ether solutions) and the absorption curves were nearly identical with maxima near 270 mμ.

(c) Both the cephalin isolated from stored egg powders and from the reaction product of cephalin and acetaldehyde were shown to be highly fluorescent. Dutton and Edwards *(7)* found an approximate linear relationship between the absorption at 270 mμ and the relative fluorescence coefficients, suggesting identity of the fluorescent and ultraviolet-absorbing moieties. These measurements were made on the acid- aqueous fractions which remained after saponification and ether extraction from acidic aqueous solution. Neither the unsaponifiable fraction nor the ether extract contained fluorescing substances.

The postulated cephalin-aldehyde reaction achieved considerable significance when Fevold, Edwards, Dimick, and Boggs *(10)* reported that the auto-deterioration of the phospholipid fraction was probably the sole cause of off-flavor development in dried eggs, and Boggs, Dutton, Edwards, and Fevold *(4)* reported that lipid fluorescence, as a measure of the phospholipid deterioration, correlated well with palatability measurements. Both Dutton and Edwards *(7)* and Fevold et al. *(10)* suggested that the unknown aldehyde arose from fat oxidation, possibly in the phospholipid itself. However, these workers did not provide information on the nature and origin of the postulated aldehyde and did not report whether cephalin prepared from egg powders stored in the absence of oxygen behaved similarly. Makower and Green *(21)*, while studying the rate of oxygen uptake by whole egg powders at different temperatures, observed that control samples, which were kept in a nitrogen atmosphere, exhibited more marked visible browning than the corresponding sample exposed to oxygen. Upon fractionation of these samples they found that the phospholipid fraction from the control nitrogen-packed powder was visibly browner than that isolated from the oxygen-packed sample, and showed much greater ultraviolet absorption as measured in ether solution.

These observations suggested to the present authors that the hypothesis for the origin of the postulated aldehyde by oxidation was not tenable; and there seemed to be no a priori reason for not considering the known aldehydic constituent of egg, glucose, to be the responsible aldehyde. Certainly the hydrophilic nature of the phosphoric-ethanolamine portion of the cephalin molecule would not preclude such a possibility.

The evidence to be presented here for an interaction between glucose and cephalin in dried whole eggs is based on the reduction or elimination of storage changes associated with cephalin by the removal of glucose prior to drying. These changes include: visible browning of the phospholipid fraction, decrease in amino nitrogen of the phospholipid fraction, increased fluorescence and increased absorption in the ultraviolet range of the total lipid or the phospholipid fraction itself.

METHODS

Preparation of Whole Egg Powders. Removal of Glucose. Most of the powders were prepared by lyophilization of well-mixed whole egg melange prepared from fresh Grade AA shell eggs. One set of powders, however, was prepared in a commercial plant by spray-drying in a Gray-Jensen type dryer some frozen whole egg melange which had been thawed just prior to processing. The moisture contents of the powders prepared were adjusted by distillation in vacuo into the powders of the calculated water increment. Glucose removal before drying was accomplished by a 2 to 3 hour resting cell yeast fermentation of the whole egg melange with either *Torula monosa* or *Saccharomyces cerevisiae;* the method is described in detail elsewhere *(15)*. In the laboratory-scale preparation of the glucose-free powders, the melange was lyophilized immediately upon completion of the fermentation. The fermented melange used in the preparation of the spray-dried powder was pasteurized for 3 to 4 minutes at 61° C. (142° F.) immediately after the fermentation and just prior to spray-drying.

Storage Experiments. The powders were stored either in sealed vacuum desiccators or in hermetically sealed cans. In those cases where the powders were stored in a nitrogen atmosphere, the containers were evacuated and flushed several times with oxygen-free nitrogen before filling. The oxygen impurities were removed from water-pumped nitrogen by passing the gas over freshly reduced copper filings heated to about 400° C. (750° F.). High purity, 99.99 percent commercial nitrogen (Linde) was also used without further purification.

Fractionation of the Ether Extracts. Twenty-gram samples of egg powder were Soxhlet-extracted with peroxide-free ether for 6 to 8 hours. The extracts were made up to volume, usually to 250 ml., and an aliquot removed for lipid fluorescence measurements. The remainder was concentrated on a steam bath without boiling under a strong air draft to about 20 ml. This was then chilled in ice-water, and 60 ml. of ice-cold acetone was added to precipitate the phospholipids. The acetone-ether slurry was permitted to set for 1 hour in a refrigerator; the phospholipids were then centrifuged out in a centrifuge operating at 2-4° C. (35-40° F.). The supernatant liquid was decanted and the phospholipid residue was kneaded thoroughly twice and centrifuged with about 30 ml. of chilled acetone. After the last washing was decanted, the solvent was removed by evaporation in vacuo.

As estimated from analyses for total phosphorus and choline, approximately 90 percent of the total phospholipid was precipitated by this method. Of the total lipid extracted by ether, about 87 percent was recovered in the acetone-soluble fraction and 13 percent as phospholipid. Analyses of the acetone-insoluble fractions prepared in this manner indicated that they were comprised of at least 95 percent phospholipid (lecithin plus cephalin). These preparations consistently contained close to 1.72 percent nitrogen and 3.85 percent phosphorus, with the molecular N/P ratios falling in the range from 1.00 to 1.06. The phospholipid mixtures averaged approximately 38 percent

cephalin as estimated from the ratio of amino-N/total N and 60 percent lecithin as estimated from the choline/total P ratio.

The acetone-soluble fractions were concentrated by evaporating off most of the solvent on a steam bath in a strong air draft followed by evaporation in vacuo.

Spectrophotometric Measurements. The absorption spectra measurements were carried out on the various extracts with a Cary recording spectrophotometer (Model 11) over the range of 250 mμ to 500 mμ. The experimentally determined absorbancy (optical density) data are reported in terms of the function used by Dutton and Edwards *(7)*, $E^{1\%}_{1\,cm.} = \frac{\log I_o/I}{cd}$, where c represents the extract from 1 g. of dried egg in 100 ml. of solution and $d = 1$ cm. The measurements reported here were made on solutions containing the extract from 4 g. of dried egg in 100 ml. of ether and are therefore reported as $E^{1\%}_{1\,cm.} \times 4$. For the absorbancy measurements on the acetone-soluble fractions of the ether extracts, the acetone-soluble oil was dissolved in ether to give the same concentration as this fraction had in the original ether extract; hence the results were also reported as $E^{1\%}_{1\,cm.} \times 4$.

The absorption measurements on ether solution of the isolated phospholipid fractions are for convenience reported as the observed absorbancy at the concentration used.

Fluorometric Measurements. These measurements were carried out using a Coleman electronic photofluorometer with filters B1 and PC1 (excitation was by the 365 mμ mercury line). The fluorescence standard was a solution of quinine sulfate dissolved in 0.1*N* sulfuric acid at a concentration of 0.4 microgram per ml. Blank readings for the solvents were subtracted from the observed readings. For the whole ether extracts and the ether solution of the acetone-soluble fractions, a function designed by Dutton and Edwards *(7)* as the relative fluorescent coefficient, Φ, was calculated by the equation $\Phi = \frac{100\ I_s/I_{qu}}{c}$, where I_s/I_{qu} is the ratio of fluorescence intensity of sample to that of standard quinine solution, and c is the concentration in grams of egg powder extracted per liter of solution. For these measurements the instrument was routinely set at a scale reading of 100 for the quinine standard. For the fluorescence measurements of the phospholipid fractions dissolved in ether, the actual scale readings at the concentration cited are reported. However, the instrument was also set in this case at a scale reading of 100 for the quinine standard.

Analytical Methods. For amino nitrogen determinations, the phospholipid preparations were dissolved or suspended in glacial acetic acid and 1 ml. aliquots were used for analyses according to the manometric method of Van Slyke. Five-minute reaction times were used since preliminary studies on freshly prepared phospholipid samples showed that this reaction time gave results which averaged within 1 percent of that obtained on the same sample after hydrolysis. For amino nitrogen determinations on the hydrolyzed phospholipids, the samples were first refluxed for 48 hours in 2*N* H_2SO_4. The fatty acids were removed by filtration, washed with hot 2*N* H_2SO_4, and the filtrate made up to volume with 2*N* H_2SO_4. One ml. of the hydrolyzate plus 1 ml. of 2*N* H_2SO_4, or 2 ml. of hydrolyzate, were used in the analysis, and a 3-minute reaction time sufficed.

Glucose determinations on the whole egg powders were performed according to the reducing sugar procedure of Somogyi *(28)*, with $ZnSO_4$ plus $Ba(OH)_2$ as the precipitating agents for interfering substances.

Choline in the phospholipid preparations was determined according to a modification of the method of Glick *(12)*.

EXPERIMENTAL RESULTS AND DISCUSSION

The results of a simple storage experiment shown in Table 1 serve to illustrate the magnitude of the changes associated with the lipid fraction. The decrease in the glucose content of the powder during the 5-week storage period is also illustrated.

TABLE 1

The Effect of Storage on Changes in the Glucose Content and in the Lipid Constituents of Dried Whole Egg [b]

	Glucose	Fluorescence of ether extract	Absorption of ether extract at 300 mμ	Ratio amino-N to total N phospholipid fraction
	in powder, %	Φ	$E^{1\%}_{1\,cm.} \times 4$	
Control (kept at −20° F.)	1.23	0.4	0.27	0.34
5 weeks, 75° F.	0.88	0.9	0.36	0.32
5 weeks, 100° F.	0.15	4.4	0.94	0.22

[b] Lyophilized; 3.7% H_2O.

It is seen that storage for 5 weeks at 38° C. (100° F.) resulted in large increases in the fluorescence intensity and ultraviolet absorption of the ether-extracted lipid. These changes were accompanied by a loss of amino nitrogen in the phospholipid fraction of the ether extract. The corresponding changes during storage at the lower temperature, 24° C. (75° F.), were of much lower magnitude, making it apparent that the reactions responsible for the changes in the lipid fraction have a large temperature coefficient between 24° and 38° C. (75° and 100° F.).

Phospholipid Fraction as the Source of Fluorescence and Ultraviolet Absorption in Ether-Extracted Lipids. Edwards and Dutton *(9)* observed that the cephalin part of the phospholipid fraction exhibited higher fluorescence and ultraviolet absorption per unit weight than the whole ether extract of stored dried eggs. However, they did not show quantitatively how much of the fluorescence and ultraviolet absorption was in the phospholipid fraction. In the present work, the increases in fluorescence and ultraviolet absorption, as measured on the ether extract, were found upon fractionation to reside almost completely in the phospholipid fraction. These results also have permitted us to use measurements performed on the ether extract as indicative of changes actually occurring in the phospholipid fraction; hence they are reported at this time.

First, with regard to fluorescence development, it is clear from the results in Table 2 that the increases in

TABLE 2

Phospholipid Fraction as Source of Fluorescence in Ether-Extractable Lipid

Sample [c]		Storage period at 100° F.	Fluorescence of whole ether extract	Fluorescence of acetone-soluble fraction	Fluorescence of acetone-insoluble (phospholipid) fraction-0.1 mg./ml. ether
Moisture content	Stored in				
%			Φ	Φ	*Scale reading*
(Control)	....	0	1.2	1.8	2.0
2	N_2	1 month	15.5	1.3	38.5
2	air	" "	14.2	1.5	33.5
5	N_2	" "	18.0	1.2	42.5
5	air	" "	16.2	1.2	38.0
(Control)	....	0	1.0	1.4	2.0
2	N_2	3 months	26.8	1.1	65.0
2	air	" "	22.8	1.7	55.0
5	N_2	" "	27.5	2.3	67.5
5	air	" "	23.0	0.8	55.0
(Control)	....	0	0.6	1.9	2.4
2	N_2	6 months	30.0	2.3	92.5
2	air	" "	25.0	1.3	60.0
5	N_2	" "	29.0	1.7	75.0
5	air	" "	24.0	1.3	65.0

[c] All samples were normal glucose-containing lyophilized whole egg powders. Control samples were prepared from the same batch of liquid egg and kept at 34° C. (−30° F.)

lipid fluorescence during storage occur in the phospholipid fraction. Even after 6 months' storage at 38° C. (100° F.), the acetone-soluble fractions did not show a significant increase in fluorescence intensity, whereas a 30- to 40-fold increase was obtained for the phospholipids in the same period. The results shown in Table 2 also make it evident that storage in the presence of air is not necessary for the development of lipid fluorescence; thus in every case the lipid fluorescence increase in the nitrogen-packed powder was as high as, or higher than that for the corresponding air-packed one.

Secondly, the increased absorption in the ultraviolet, as measured on the total ether-extracted lipids, was similarly attributable to changes in the phospholipid fraction (Figure 1). The absorption curves in Figure 1 are for the ether extracts from a control egg powder sample kept at —34° C. (—30° F.) and two stored powders,

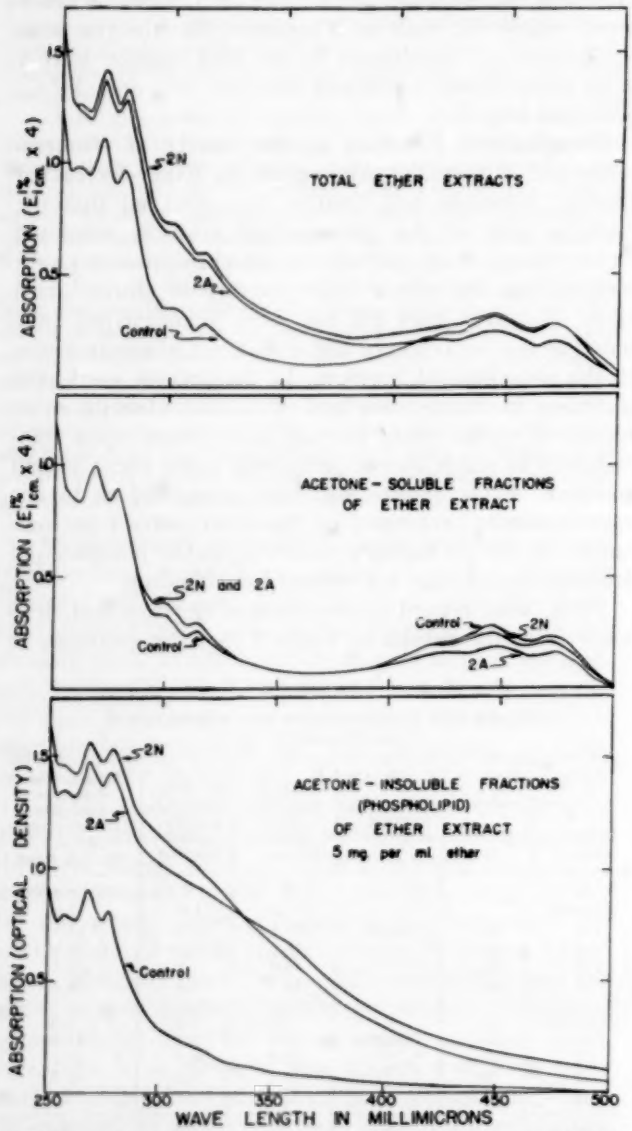

FIG. 1. Absorption spectra of whole ether extracts and the acetone-soluble and acetone-insoluble fractions prepared therefrom. Ether extracts and fractions from three samples of normal (glucose-containing) whole egg powder are shown. Control: Original powder kept at —30° F.; 2N: Powder containing 2 percent H_2O stored 1 month at 100° F. in N_2, and 2A: Powder containing 2 percent H_2O stored 1 month at 100° F. in air.

one of which was stored at 38° C. (100° F.) for 1 month in air and the other under identical conditions but in a nitrogen atmosphere. It is also evident from these curves that the increased absorption in the ultraviolet is not mainly due to an oxidative reaction, since the increase observed for the sample stored in nitrogen was of the same order of magnitude as that stored in air.

The whole ether extract and the acetone-soluble fraction therefrom, prepared from the air-packed sample, did show decreased absorption in the vicinity of 445 mμ. This was almost certainly due to an oxidative loss in carotenoids.

Effect of Glucose Removal on Phospholipid Deterioration. It has been shown above that the increases in fluorescence intensity and absorption of the total lipid material in the ultraviolet range are due almost entirely to changes in the phospholipid fraction. That these increases involve cephalin rather than lecithin follows from the observations of Dutton and Edwards *(7, 9)*, who showed that the fluorescence and browning of the phospholipid fraction are due largely to cephalin. The data to be presented now show that removal of glucose before drying practically eliminates these changes.

The interaction between glucose and phospholipid may be accomplished by simply heating egg powders in vacuo. Two powders, both prepared by spray drying from the same batch of liquid egg melange, but one of which was rendered glucose-free by yeast fermentation prior to drying, were heated 5 hours at 98° C. (208° F.) in vacuum of below 0.2 mm. Hg. This was done in the course of moisture determinations on certain samples. Both powders contained 5.3 percent H_2O initially. The effect of the heat treatment on the glucose content and total lipid fluorescence is shown below:

	Glucose in powder	Fluorescence of ether extract
	percent	Φ
Unfermented powder—Before heating	0.93	0.6
" " After heating	0.37	52.5
Fermented powder—Before heating	0.03	0.5
" " After heating	....	4.1

Changes in the absorption spectra of the ether extracts from these samples are shown in Figure 2.

These data show that a number of changes in the lipid constituents accompany the loss of glucose in the normal powder, but do not occur to any great extent in glucose-free powder. These changes include: increase in fluorescence intensity, increase in ultra-violet absorption, and visible browning.

The interaction between glucose and cephalin occurring during the storage of whole egg powders is evident in the results of some other storage experiments. Thus, the data in Table 3 show that glucose removal practically eliminates the major deteriorative changes which occur in the phospholipid fraction of the normal, glucose-containing powders. The phospholipids from glucose-free powders show little evidence of browning in contrast to the intense darkening observed with the phospholipids prepared from the normal powder. A rough measure of the extent of the browning is indicated by the data showing the absorption in ether

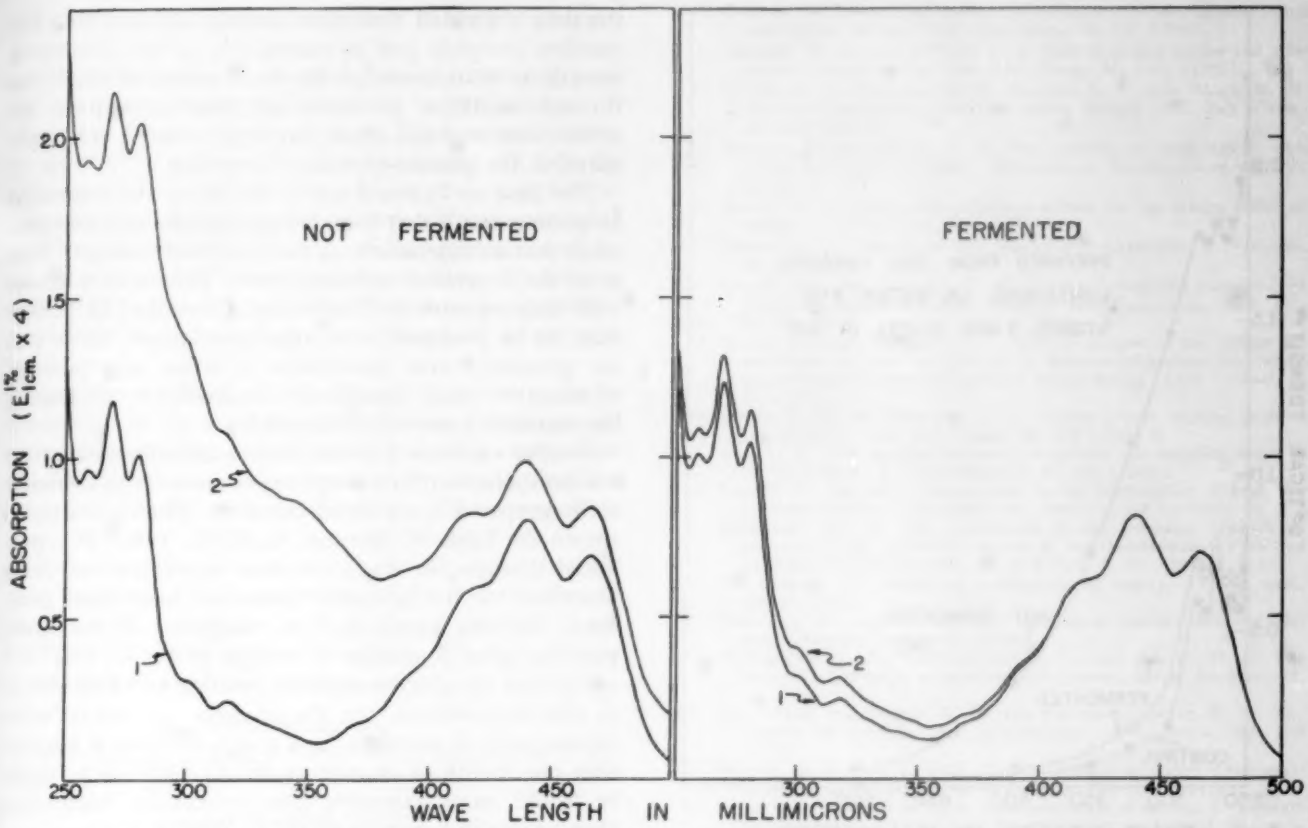

FIG. 2. Effect of heating in vacuum (< 0.2 mm. Hg.) for 5 hours at 98° C. on the absorption spectra of the ether extracts from two spray-dried whole egg powders; a normal (glucose-containing) powder and a fermented (glucose-free) one. Both powders were prepared from the same batch of liquid whole egg melange and contained 5.3 percent H_2O before heating. 1: Before heating; 2: After heating.

solution at 500 mμ (Table 3). It will be noted that the phospholipids prepared from the normal powders stored in nitrogen consistently show more absorption than their counterparts prepared from a normal powder stored in air. This was also obvious from direct visual examination. The phospholipid from the nitrogen-packed powders appeared much darker than the air-packed counterparts.

The development of fluorescence and increase in ultraviolet absorption at 300 mμ (Table 3) are also nearly prevented by glucose removal before drying. Figure 3 illustrates the effect of glucose removal on the absorption curve for wave lengths from 250 to 500 mμ.

More direct evidence of the effect of glucose on the cephalin deterioration is offered by the amino-nitrogen analyses performed directly on the phospholipid fractions (Table 3). Glucose removal practically prevented the loss in amino nitrogen occurring in the powders containing 2 percent moisture. At the higher moisture content of 5 percent, the loss in amino nitrogen is retarded but not prevented. Apparently other reactions, perhaps of a polymerization nature *(5)*, are active in the latter case in blocking or destroying the free amino group of the cephalin molecule. Analyses for amino nitrogen on the phospholipid preparations after hydrolysis showed that, for the phospholipids prepared from

TABLE 3

Effect of Glucose Removal on the Phospholipid Changes in Lyophilized Whole Egg Stored Under Various Conditions [a]

Sample		Storage period	Glucose		Fluorescence of whole ether-extract Φ		Phospholipid Analyses					
							Ratio NH_2-N to total-N		Absorption at 500 mμ 10 mg./ml. ether		Absorption at 300 mμ 2 mg./ml. ether	
Moisture content	Stored in											
%		*Weeks*	*In powder, %*									
			U [b]	F [c]	U	F	U	F	U	F	U	F
(Control)	....	0	1.33	0.03	1.4	1.5	0.34	0.35	0.03	0.03	0.12	0.10
2	N_2	4	0.46	....	13.0	2.0	0.25	0.33	0.21	0.04	0.41	0.11
2	air	4	0.48	....	12.4	2.6	0.26	0.33	0.11	0.04	0.46	0.14
5	N_2	4	0.08	....	14.6	2.1	0.22	0.28	0.23	0.04	0.41	0.11
5	air	4	0.08	....	13.2	2.3	0.23	0.28	0.10	0.03	0.39	0.11
(Control)	....	0	1.28	0.03	1.8	1.5	0.35	0.32	0.02	0.02	0.15	0.13
2	N_2	8	0.37	....	17.4	2.6	0.22	0.32	0.31	0.03	0.60	0.16
2	air	8	0.36	....	17.2	4.3	0.23	0.30	0.14	0.02	0.60	0.20
5	N_2	8	0.05	....	16.6	2.6	0.20	0.24	0.30	0.03	0.54	0.14
5	air	8	0.05	....	17.0	3.2	0.18	0.24	0.13	0.02	0.51	0.16

[a] Storage at 100° F. [b] Unfermented, normal glucose-containing powder. [c] Fermented glucose-free powder.

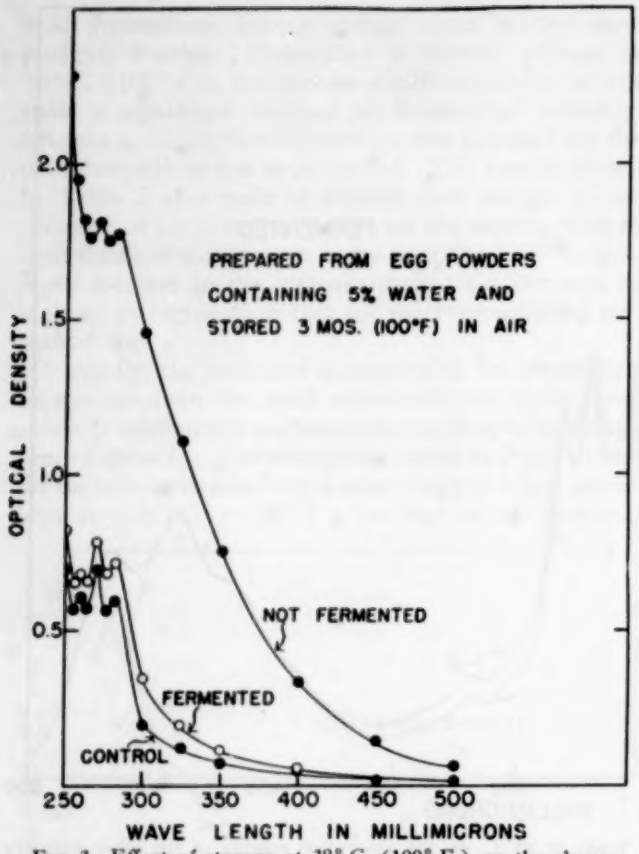

FIG. 3. Effect of storage at 38° C. (100° F.) on the changes in absorption spectra of the phospholipid fractions from a normal (glucose-containing) and a fermented (glucose-free) egg powder. Absorption measurements were performed on ether solutions containing 5 mg. of phospholipid per ml.

the glucose-free powders, approximately 99 percent at the 2 percent moisture level and 90 percent at the 5 percent moisture level of the amino nitrogen lost during storage were recovered by hydrolysis. The corresponding values for the hydrolyzed phospholipids from normal glucose-containing powders were 82 percent and 69 percent, respectively. These results suggest that the glucose-induced loss in amino nitrogen is a more destructive reaction than that responsible for the loss of amino nitrogen in the phospholipids contained in the 5 percent moisture glucose-free powder.

The various results reported in Table 3 indicate an aldehyde interaction with cephalin, inasmuch as Dutton and Edwards *(7, 8)* found that reaction between acetaldehyde and cephalin produced similar changes. Since the data presented here offer strong evidence that the reaction proceeds just as extensively in the absence of oxygen as in its presence, the development of aldehydes through oxidative processes and their subsequent reaction with cephalin must play only a minor role compared to the glucose-cephalin interaction.

The data in Tables 2 and 3 also show the somewhat surprising result that the glucose-cephalin reaction proceeds just as extensively at the 2 percent moisture level as at the 5 percent moisture level. This is at variance with data reported by Dutton and Edwards *(8)*. Other data, to be presented in a subsequent paper, show that the glucose-protein interaction in whole egg powder, on the other hand, is markedly diminished by decreasing the moisture content of the powder.

Similar evidence for the glucose-cephalin interaction has been obtained in storage experiments with commercially prepared spray-dried powders. These results are shown in Table 4. Storage at 38° C. (100° F.) produced changes in these powders equivalent to those described for the laboratory-prepared lyophilized powders. Results obtained from analyses of the same powders after 5 months of storage at 16° C. (60° F.) reveal that the glucose-cephalin reaction proceeds slowly at this temperature, but the changes are nevertheless definite after 5 months. As a rough estimate it appears that one month of storage at 38° C. (100° F.) results in 5-fold more extensive glucose-cephalin interaction than occurs in 5 months at 16° C. (60° F.).

The evidence presented here is not intended as proof for a reaction between glucose itself and cephalin. It is possible that such degradative products of glucose decomposition as hydroxymethyl furfural, methyl glyoxal, or acetol may be more directly involved. The essential point of the evidence is that the major part of the cephalin deterioration occurring during the storage of dried eggs is glucose-induced.

SUMMARY

The following changes in the phospholipid fraction which occur during the storage of whole egg powder have been found to be practically eliminated by removal of glucose from the liquid before drying. These are:

1. Visible browning of the total lipid or phospholipid fraction.
2. Development of fluorescence in the total lipid or phospholipid fraction.
3. Increased ultraviolet absorption by the total lipid or phospholipid fraction.

TABLE 4

Effect of Glucose Removal on the Phospholipid Changes in Spray-Dried Whole Egg Stored Under Various Conditions [a]

Sample		Storage	Glucose		Phospholipid Analyses							
Moisture content	Stored in		Fluorescence 0.1 mg./ml. ether		Absorption 500 mμ 10 mg./ml. ether		Absorption 360 mμ 10 mg./ml. ether		Absorption 300 mμ 2 mg./ml. ether	
%			*In powder, %*		*Scale reading*							
			U [b]	F [c]	U	F	U	F	U	F	U	F
(Control)	....	0	1.07	0.03	3.7	3.3	0.02	0.02	0.14	0.17	0.10	0.13
5	N_2	5 wks. at 100° F.	0.06	....	42.5	6.7	0.23	0.03	1.30	0.22	0.40	0.14
5	air	" " " "	0.06	....	40.8	7.7	0.16	0.03	1.13	0.26	0.40	0.17
(Control)	....	0	1.05	0.03	2.8	1.8	0.03	0.02	0.13	0.12	0.08	0.09
5	N_2	5 months at 60° F.	0.33	....	15.0	2.7	0.07	0.03	0.39	0.14	0.15	0.09
5	air	" " " "	0.38	....	10.5	3.5	0.05	0.03	0.38	0.17	0.17	0.11

[a] Commercially spray-dried whole egg. [b] Unfermented normal glucose-containing powder. [c] Fermented glucose-free powder.

4. Loss in amino nitrogen content of the phospholipid fraction.

These changes in the normal glucose-containing powder are not significantly influenced by the presence or absence of oxygen during storage. Nor are they induced by storing the glucose-free powders in air. In fact, the amount of "browning" observed in the phospholipid fractions isolated from the stored glucose-containing powders, estimated both by visible inspection and by spectrophotometric measurements of ether solutions at from 400 to 500 mμ, has been shown to be invariably greater in the case of powders stored in a nitrogen atmosphere.

Previous workers *(7, 8)* showed that the cephalin component of the total phospholipid was the compound undergoing storage deterioration and additionally that this deterioration could be simulated by reacting freshly-prepared cephalin with acetaldehyde. Their suggestion of an oxidative origin for the reactive aldehyde is not confirmed by the present results, which show that the most rapid reaction contributing to the deterioration of phospholipid during the storage of egg powders is indeed a lipid amine-aldehyde reaction, but that glucose is the reactive aldehyde involved.

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Top-Inlet Heating of Retorts and Spray Cooling of Glass Jars in Community Canneries

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Measurements of temperatures existing in No. 3 retorts under regular operating conditions in community canneries showed that the temperatures vary widely and are often dangerously low for safe processing of low acid foods. Admission of steam at the top of the retort instead of the bottom resulted in more rapid come-up times and greater uniformity of temperature. Less steam was also consumed with top inlet heating. Spraying procedures for glass jars are described. Breakage should not exceed 0.2 percent under regular community canning conditions.

The federal and the various state community cannery programs arose in part because there was a need for a method of food preservation which would enable families to can their own produce more cheaply and surely than at home. This need plus the secondary function of canning surplus crops for school lunch programs has

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resulted in the development of community canning programs upon a sizeable scale in at least 16 states.

In spite of the growth of the community cannery system, the processing procedures followed are still those originally adopted from home or commercial sources. Although attempts are made to follow the general principles basic to proper processing as developed mainly by the commercial industry, the soundness of some common practices, particularly retort hook-ups and operative techniques, are questionable from the point of view of safety and efficiency.

Fitzpatrick, McConnell, and Esselen *(5)* were apparently the first to study temperature distribution in community cannery size retorts and to make recommendations based upon experimental study. The retorts were heated with steam admitted at the bottom through a $\frac{7}{8}$" pipe and vented through a $\frac{3}{16}$" or $\frac{3}{8}$" bleed valve at the top. They recommended that No. 2 retorts be vented at least 7 minutes at 10 pounds pressure, No. 3 retorts be vented 25 minutes at 0 pounds or 10 minutes at 10 pounds pressure, and that the bleed valve be $\frac{3}{8}$" or larger. Their findings are the backbone of the directions for venting retorts contained in the Production and Marketing Administration's manual, "Community Canning Centers" *(1)*.

Ford *(6)* and Powers and Mills *(9)* developed methods of hooking up No. 2 and No. 3 retorts with top-inlet steam and outlined procedures to be followed in operating the retorts. The use of top-inlet steam has been reported to result in more uniform temperature distribution in commercial size retorts than the use of bottom inlet steam *(2, 3, 4, 7,* and *8)*. White and Chavous *(10)* compared steam consumption when No. 3 retorts were heated from the top and the bottom.

EXPERIMENTAL

The study was divided into four phases: (a) investigation of the uniformity of temperature distribution in retorts in community canneries under regular operating conditions, (b) laboratory examination of bottom inlet heating where conditions could be reproduced, (c) exploration of top inlet heating methods in the laboratory and in the field, and (d) evaluation of methods of cooling glass containers after processing.

Twelve or thirteen thermocouples were used for each temperature distribution determination. A Leeds and Northrup potentiometer with an external reference junction was used throughout the investigation. In the field the thermocouples were scattered throughout the retort. In the laboratory the thermocouples were concentrated in two tiers of containers at a time in various combinations until each tier had been examined at least in triplicate. The laboratory runs were made with both experienced and inexperienced retort operators to ascertain the extent to which the retort operator could affect the results even though he apparently followed a standard procedure.

Most of the retorts hook-ups with bottom heating followed the most common field practice and the one recommended by some agencies. Steam entered the retort through a ¾" pipe connected to a tee at the bottom of the retort. The drain (condensate) line led from the opposite side of the tee. A ¼" petcock was used for venting at the top. Variations of this hook-up consisted of draining the condensate through a pipe separate from the steam line and of varying the size of the top vent.

The top-inlet method of heating consisted of admitting steam through two or three ¼" lines equally spaced around the top of the sidewall of the retort. The condensate and air was vented through a ¾" pipe at the bottom with a gate valve. A ¼" petcock was placed in the drain line between the retort and the gate valve. Figure 1 shows the hook-up. In operation, the gate valve was left wide open until the retort theremometer registered at least 100° C. (212° F.); it was then closed, but the ¼" petcock was left open throughout the cook to permit the condensate and non-condensable gases to vent.

The spray cooling procedures consisted of attaching various size spraying nozzles to water lines entering the retort through the lid. The nozzles were of a type that distributed the water uniformly over the entire area covered by the spray. Air pressure was used during cooling. The spraying system is shown in Figure 1.

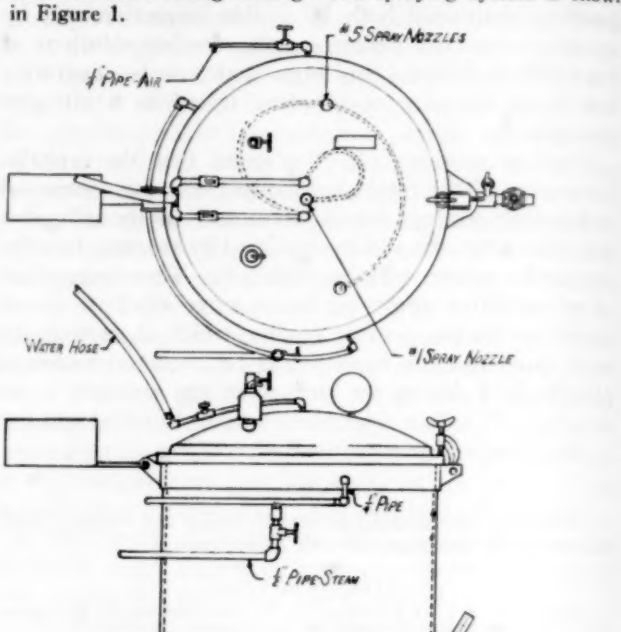

Fig. 1. Diagram of retort hook-up and spray system.

RESULTS

An alarming degree of mis-operation of retorts was noted when temperature distribution studies were made in community canneries. At each cannery the regular retort operator was requested to operate the retort exactly as he normally would. Figure 2 shows the erratic temperature distribution observed in one cannery. There were no thermometers on the retorts, the pressure gauge on the retort within which the temperature distribution measurements were made was inaccurate, and the retort operator failed to drain off any condensate with the result that the condensate apparently cooled the cans in the lower part of the retort during the come-up period. Note in Figure 2 lines 3, 5, 9, and 11 which show the temperature existing at the four thermocouples in the lowest tier of cans.

In some plants, good temperature distribution was observed; too often, however, it was as poor or nearly as poor as that shown in Figure 2. When faults were pointed out to the retort operators, they were eager to correct them. Failure of the operators to understand the basic principles of pressure processing was the primary cause of the poor retort practices, but they were not solely responsible for the mis-operation found. The Community Canning Center's Manual (1946 edition), for example, instructs the operator to make certain that the drain valve is closed before turning on the steam. This same edition also shows a retort hooked up with the steam entering at the bottom

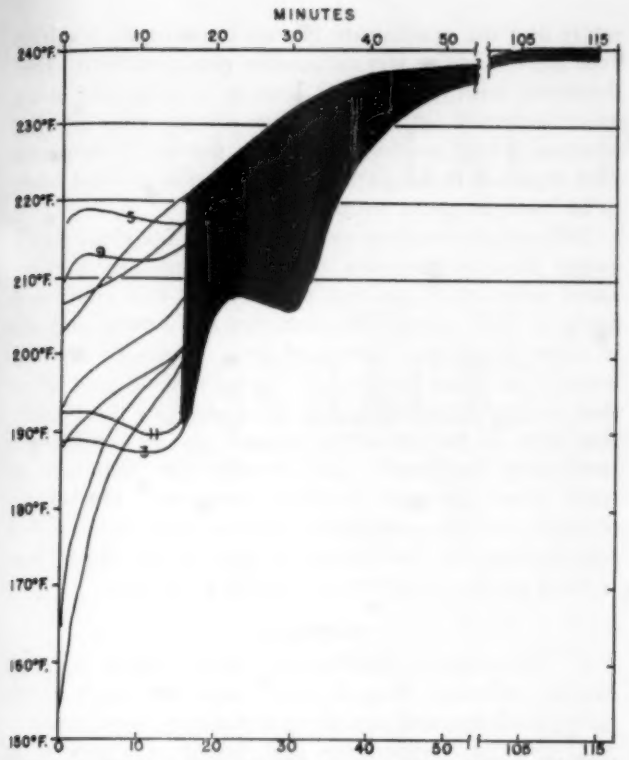

FIG. 2. Temperature distribution in a No. 3 retort loaded with No. 2 cans of cream-style corn. Bottom steam inlet. Retort pressure gauge at 13 pounds during processing period. Range of temperatures existing during processing period shown as solid area. Note that lines 3, 5, 9 and 11 (representing thermocouples in the lower portion of the retort) show cooling during the coming-up period.

through a tee and pipe through which the condensate must also drain. The venting directions were derived, however, from temperature distribution measurements made in retorts with separate steam and drainage lines. The previous edition of this manual (1944) showed separate steam and condensate lines.

Temperature Distribution with Bottom Inlet Heating. The findings of Fitzpatrick, McConnell, and Esselen *(5)* were substantiated with bottom inlet heating in the laboratory. These workers were restricted to 15 pounds steam (because of the boiler regulations in Massachusetts) for the thin walled vessels then being manufactured. They suggested that the venting times they recommended might be reduced if higher pressure steam was used. In our study, steam ranging from 18 to 55 pounds pressure was used. Runs were observed in which the retorts were fully vented in five minutes with 38 pounds of steam, but poor venting was also encountered under apparently the same conditions. Possibly slight differences in stacking the containers or placing the retort crate off-center affected the flow of steam so that air pockets resulted. Because such variations are normal, the venting time should be long enough to flush out the most persistent air pockets; thus the venting times Fitzpatrick, McConnell, and Esselen *(5)* suggest for low pressure steam should be applied to pressure up to 40 pounds to insure the invariable removal of air. When condensate is drained through the same pipe as the entering steam, 15 minutes venting under pressure should be the minimum for No. 3 retorts.

Top-Inlet Heating. Retorts attained uniform temperature more rapidly with top inlet steam than with bottom inlet steam. With top inlet steam the retort could be brought from room temperature to 115.6° C. (240° F.) in about 15 minutes. When bottom-inlet heating was used with the same come-up time, the center of the top tier of containers was generally only at 110° C. (230° F.) at the end of the come-up time and other locations at the top of the retort were about three degrees below the desired temperature, which is 115.6° C. (240° F.).

To demonstrate the rapidity with which top-inlet steam clears a retort of air, a regular run was started, then air was injected into the retort at the bottom. While air was being injected the temperatures varied widely as might be expected, but when the air was shut off, the top inlet steam cleared the retort of air within four minutes.

Top-inlet heating resulted in decreased steam consumption. The amount of condensate collected when 95 quarts of water initially at 21.1° C. (70° F.) were processed at 115.6° C. (240° F.) for 40 minutes averaged 54 pounds for 20 determinations. The average for 20 bottom-inlet determinations was 58 pounds. The difference was statistically significant at the 5 percent level. The decreased steam consumption observed agrees with the findings of others *(4, 6,* and *10)*.

Using eleven thermocouples per determination, five comparisons were made between the rate of heat penetration into quart jars of green beans heated with top and bottom-inlet steam. Figure 3 shows that top-inlet heating resulted in more uniform

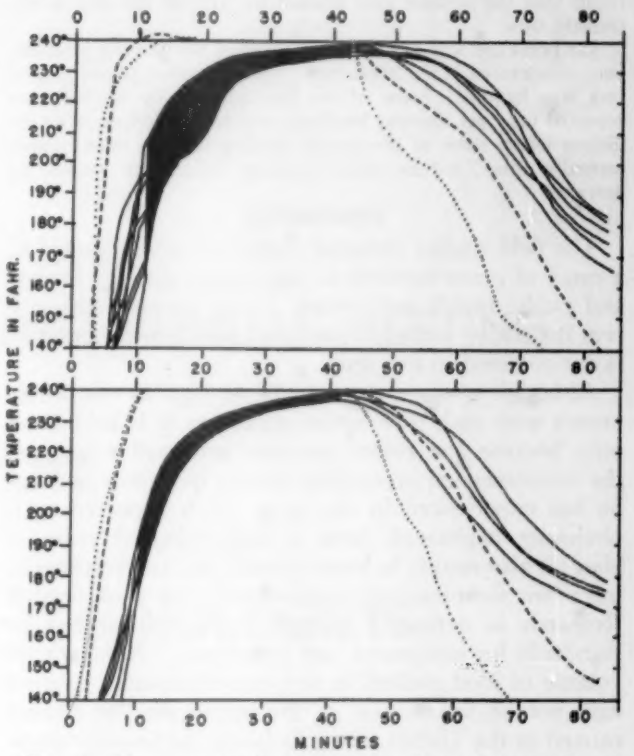

FIG. 3. Heat penetration into quart jars of green beans. Spray cooled. Dotted lines, thermocouple at top of retort outside of jar; broken lines, thermocouple at bottom of retort outside of jar. Upper figure shows bottom-inlet steam, lower figure shows top-inlet steam.

heat penetration than bottom-inlet heating with the same come-up time. When the proper, but longer, vent required to clear the retort of air with bottom inlet heating was used, the range of temperatures within the jars was not much greater than that of the top inlet heated jars.

Spray Cooling of Glass Jars. The processing phases of the study consisted of the development of methods whereby spoilage would be minimized and quality improved. The cooling phase was concerned with these objectives and the additional one of determining whether glass jars could be handled rapidly and easily in community canneries so as to reduce container cost through re-use of the container.

In the past some plant operators have discouraged the use of glass jars because the retorts could not be blown down rapidly to permit immedate re-use of the retort. With glass containers, the retorts had to be allowed to cool slowly so as to avoid loss of liquid or else accept loss of liquid and the danger of burns from venting liquid if the retort was opened prematurely. Water cooking and cooling under pressure, although faster, is still too slow.

Cooling was effected by spraying a very fine mist of water onto the jars after processing. A small, high capacity, low

pressure air compressor was used to maintain pressure in the retort until the initial temperature (and pressure) of the jars was reduced below the venting point of the closure. In practice, a No. 1 spray (delivering about 0.2 gallons of water per minute) was turned on until the retort temperature fell to 87.8° C. (190° F.). Then two No. 5 sprays (each delivering about 0.9 gallon per minute) were also turned on until the retort temperature reached 71.1° C. (160° F.). At this point the retort could be opened and the jars removed to a spraying chamber where a No. 10 spray (delivering about 7 gallons per minute) was used to reduce the temperature to 37.8-43.3° C. (100-110° F.). Figure 3 shows the cooling rate of the retort and green beans in quart jars. Whether tin or glass containers are used, the spray system is superior to the tank method of cooling cans because the tendency is to seldom change the cooling water, particularly in areas where water is scarce, with the result that the cooling rate toward the end of the day is extremely slow.

Jar breakage was negligible. Less than 0.5 percent breakage was encountered in the laboratory. The equivalent of over 26,000 jars was handled. Some of the jars were badly spalled from repeated use; yet thermal breakage was rare. Under plant conditions where some of the drastic cooling methods tried experimentally would not be used, breakage should not exceed 0.2 percent.

DISCUSSION

The field studies revealed conditions which should be a cause of grave concern to community cannery leaders and public health authorities. From personal observation the senior author is sure that poor retort operation is not confined to one state.

Although spoilage may not be as high as one would expect with such poor retort operation, it is held down only because the retort operator arbitrarily increases the recommended processing time to overcome spoilage he has experienced in the past. Such a procedure is obviously haphazard from a bacteriological point of view; it also results in lower quality due to overprocessing when the processor overestimates the cook needed. Research is definitely needed to establish minimum standards for equipment and procedures. Although the volume of food packed in any one community cannery may not be impressive, in the aggregate the amount canned in the United States is large. In Georgia alone, for example, the equivalent of 210,000 cases of food is canned yearly in the state's 431 community canneries. Failure to observe reasonable standards of safety from a bacteriological standpoint could lead to widespread economic loss and possibly food poisoning.

The laboratory comparisons of bottom and top-inlet heating showed that the theoretical advantages of top-inlet heating were establishable as facts. The reason retorts with top inlet heating vent more rapidly is that the natural tendency of air to settle out of an air and steam mixture is utilized. The weight of the steam overlaying the air plus the pressure of the incoming steam drives the air out the bottom without undue mixing.

Top-inlet heating consumes less steam than bottom-inlet heating because more heat is extracted from the steam. The first steam entering the retort with top inlet heating condenses on the top layers of jars. The condensate in draining to the bottom of the retort passes over cold jars thereby giving up sensible heat. With bottom-inlet heating, on the other hand, only the latent heat is extracted from the first steam entering the retort because the steam condenses near the bottom of the retort and the condensate has no opportunity to drain over the rest of the jars meanwhile giving up heat. Furthermore, with bottom-inlet heating considerable steam must be vented out the top before all the air is expelled whereas before much steam passes out the bottom vent with top-inlet heating the retort is free of air and ready to be brought up to temperature.

Although the cooling period required for glass jars is longer than for tin cans, the exhausting step is eliminated when glass jars are used. Since this study was made in 1947, about 100 canneries in Georgia and 400 in other states have converted their retorts to top-inlet heating and spray cooling. By spray cooling jars rather than air cooling, overcooking is avoided and the production rates of the canneries stepped up. In removing a production bottleneck, and thereby the objection of some plant operators to glass containers, one of the objectives of the community cannery idea, namely, low cost canning for low income groups, is met since there is not a yearly, re-occurrent cost for containers.

SUMMARY

1. Temperature distribution measurements in community canneries showed that a high percentage of the retort hook-ups and operating techniques were faulty.

2. Uniform temperature distribution was secured in No. 3 retorts more rapidly when steam was admitted at the top than when admitted at the bottom.

3. Less steam was consumed with top-inlet heating than with bottom-inlet heating.

4. Spraying procedures were developed for glass containers which permit glass jars to be cooled in community canneries quickly and without breakage. The cooling procedure also enables tin cans to be cooled more rapidly than by the cooling tanks commonly found in community canneries.

5. Irrespective of the container used, the procedures described should lead to an improvement in quality and greater freedom from spoilage.

Acknowledgments

The Food Technology Department acknowledges the financial support and cooperation of the Ball Brothers Company, Muncie, Indiana, which made possible this study. The authors thank Lionel W. Mills, Philip Greear, Thomas Davenport, Joe Hardman, and Ralph Turner for technical assistance.

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TECHNICAL PROGRAM

AND

ABSTRACTS

ELEVENTH ANNUAL MEETING

OF THE

INSTITUTE

OF

FOOD TECHNOLOGISTS

JUNE 17-21, 1951 • NEW YORK

SUMMARY OF GENERAL AND SOCIAL EVENTS

(Additional events may appear in the final program)

Saturday, June 16

Executive Committee Meetings (Parlor C).

Sunday, June 17

Council Luncheon, 12:15 p. m. (Parlor F).
General Meeting, 8:00-9:00 p. m. (Ballroom).
Social Hour, 9:00 p. m. (Ballroom)

Monday, June 18

Editorial Boards Breakfast, 7:45 a. m. (East Room).
University of Massachusetts Alumni Luncheon, 12:15 p. m. (Parlor D).
Theatre Party "Out of This World," 8:30 p. m.

Tuesday, June 19

Awards Luncheon, 12:15 p. m. (Ballroom).
Nicholas Appert Award Dinner, 7:00 p. m. (Ballroom).

Wednesday, June 20

Business Meeting Luncheon, 12:15 p. m. (Ballroom).

Thursday, June 21

Field Trips.

A SPECIAL MESSAGE FROM THE PROGRAM COMMITTEE

One of the important goals of every industry is service to the consumer. Production men and scientists are daily seeking to meet consumer needs.

This year, we wish to bring the consumer into our convention. The food industry is seeking to determine the reaction of the consumer to its products. Closer cooperation between the producer and the consumer is necessary in order that we food technologists may function to the best interest of all concerned.

We are holding our meeting in the center of the greatest consumer area in the world. It is therefore fitting that we should have on our general program several speakers who will integrate the ideas of the consumer, the manufacturer, the nutritionist, and the economist in respect to the problems of the food industry. To expand this field, we have also planned a program covering consumer acceptance for the purpose of increasing interest in the use of more satisfactory methods of appraising the ideas of the homemaker.

Packaging is one of the important problems in the food industry; nutritive properties, consumer appeal, economy are all involved. A number of sessions will cover this important subject.

Newer techniques in the development of instrumentation to give the manufacturer more effective control of production are also being presented. Means of concentrating fruit juices to retain flavor and nutritive value are to be the subject of discussion in one section. Methods used in predicting the effective shelf-life of manufactured products will be discussed by a group who have wide experience in this field.

Sanitation, frozen foods, cereals, citrus products, dehydrated foods, fishery products, newer developments in the meat industry, newer methods of food preservation and a list of new products recently appearing on the market will be discussed.

Approximately 50 manufacturers of equipment will have their products on display at the convention.

We sincerely hope that you will profit by the convention.

SUNDAY EVENING — JUNE 17

2:10— 1. Production Progress in the Tin Plate Industry

SUNDAY EVENING — JUNE 17

Ball Room

GENERAL MEETING

Chairman: PRESIDENT PAUL F. SHARP

8:00— Biological and Medical Implications of Atomic Weapons
DR. L. W. TUTTLE, Assistant Chief, Medical Branch, Division of Biology and Medicine, U. S. Atomic Energy Commission, Washington, D. C.

9:00— Social Hour

MONDAY MORNING — JUNE 18

Ball Room

GENERAL SESSION

Chairman: PRESIDENT PAUL F. SHARP

10:00— CALL TO ORDER—PRESIDENT PAUL F. SHARP

10:05— GREETINGS FROM NEW YORK SECTION, I. F. T.

10:10— PRESIDENT'S ADDRESS—DR. PAUL F. SHARP, Food and Agriculture

10:25— New Research Findings for Food Improvement
DR. C. G. KING

10:45— The U. S. Food Supply in Another Time of Crisis
PROF. HERRELL DEGRAFF

11:05— The Consumer's Viewpoint in Respect to Products Manufactured by Food Industries
MRS. RAYMOND W. GREGORY, District of Columbia Homemaker's Section

11:25— Making a Product Good Is Not Enough
H. J. HEINZ, 2ND, President, H. J. Heinz Co., Pittsburgh, Pa.

MONDAY AFTERNOON — JUNE 18

Section A—Ballroom

PANEL ON TIN PLATE FOR FOOD CONTAINERS

Chairman: BERTON S. CLARK

2:00— Introductory Remarks

I Production of Tin Plate

2:10— 1. Production Progress in the Tin Plate Industry
R. B. MENEILLY, Metallurgical Engineer, United States Steel Corp., Pittsburgh, Pa.

2:35— 2. Significance of Continuous Production Methods in the Manufacture of Tin Plate
E. D. MARTIN, Superintendent of Research and Development, Inland Steel Co., East Chicago, Ill.

II Use of Modern Tin Plate for the Manufacture of Food Containers

3:00— 3. Corrosion Factors Related to the Use of Tin Plate for Food Containers
R. R. HARTWELL, Assistant Chief, Container Section, Research Department, American Can Co., Maywood, Ill.

3:25— 4. Effect of Progress in Tin Plate Manufacture on the Use of Tin Plate for Cans for Foods
A. E. STEVENSON, Assistant to the General Manager of Research, Continental Can Co., Inc., Chicago, Ill.

3:50— III Discussion Period
Leader: JOHN T. KNOWLES, Vice President in Charge of Research, Libby, McNeill & Libby, Chicago, Ill.

MONDAY AFTERNOON

Section B—Panel Room

TRANSPORTATION OF FOODS

Chairman: MARY E. PENNINGTON

2:00— Introductory Remarks

2:10— 5. Temperatures Needed for the Transport of Fruits and Vegetables
W. T. PENTZER, Principal Horticulturist, Bureau of Plant Industry, U. S. Department of Agriculture, Beltsville, Md.

2:35— 6. Mechanical Refrigeration in the Transportation of Perishable Food
WALTER H. REDIT, Mechanical Engineer, Division of Fruits and Vegetable Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, Beltsville, Md.

3:00— 7. The Marine Transportation of Perishables
L. L. WESTLING, Matson Navigation Co., San Francisco, Calif.

3:25— 8. The Truck Transportation of Perishables
T. G. LUMBRA, Champlain Valley Fruit Co., Inc., Burlington, Vt.

3:50— 9. Transportation of Frozen Perishables
HAROLD C. EMERSON, Vice President, Cumberland Warehouse Corp., Bridgeton, N. J.

MONDAY AFTERNOON

Section C—East Room

CEREAL TECHNOLOGY

Chairman: R. T. BOHN

2:00— Introductory Remarks

2:10— 10. Present Status of Theory of Bread Staling
W. G. BECHTEL and D. F. MEISNER, American Institute of Baking, Chicago, Ill.

2:30— 11. Light Destruction of Riboflavin in Bakery Products
H. W. LOY, JR., J. F. HAGGERTY and E. L. COMBS, Food and Drug Administration, Federal Security Agency, Washington, D. C.

2:45— 12. The Bulk Transportation and Handling of Flour
PAUL TALMEY, The Great American Transportation Co., Chicago, Ill.

3:30— 13. Radiography Applied to Grain and Seeds
MAX MILNER, M. R. LEE and ROBERT KATZ, Kansas State College, Manhattan, Kan.

TUESDAY MORNING—JUNE 19

Section D—Ballroom

INTERPRETING THE NEWER TESTS OF PACKAGING MATERIALS

Chairman: L. V. BURTON

9:00— Introductory Remarks

9:10— 14. The Modern Concept of Food Packaging
ARTHUR S. LEVINE and I. S. FAGERSON, University of Massachusetts, Amherst, Mass.

9:25— 15. Method for Measuring Gas Tightness of Crown Closures
V. C. GUSE, Bond Crown & Cork Co., Wilmington, Del.

9:50— 16. Principles of Nitrogen Packing in Flexible Films
W. S. WALKER, Linde Air Products Co., New York, N. Y.

10:15— 17. Testing Adhesives for Food Packages
L. E. SIMERL, Marathon Corp., Menasha, Wis.

10:40— 18. A New Graphical Interpolation Method for Obtaining Humidity Equilibrium Data, with Special Reference to Its Role in Food Packaging Studies
ARTHUR H. LANDROCK and BERNARD E. PROCTOR, Massachusetts Institute of Technology, Cambridge, Mass.

11:05— 19. The Transmission of Organic Vapors Through Packaging Materials
T. J. MULDOON and F. J. SYLVESTER, General Foods Corp., Hoboken, N. J.

11:30— 20. Impact Fatigue — A Method for Predicting Bag Strength
T. J. MULDOON and R. DE S. COUCH, General Foods Corp., Hoboken, N. J.

TUESDAY MORNING

Section E—Gold Room, Manhattan Center

QUALITY CONTROL PROBLEMS

Chairman: A. G. OLSEN

9:00— Introductory Remarks

9:10— 21. Statistical Methods in Quality Control
GRANT WERNIMONT, Eastman Kodak Co., Rochester, N. Y.

9:35— 22. Statistical Quality Control of Food Plant Processing
FRANK V. KENNEY, P. Ballantine & Sons, Newark, N. J.

9:50— 23. Instruments for Objective Measurement of Quality Control Factors
B. W. CLARKE, The Crosse & Blackwell Co., Baltimore, Md.

10:05— 24. Color Measurement in Quality Control of Foods
C. C. SUTTON, R. C. AMBLER, and D. ARKIN, Central Laboratories, General Foods Corp., Hoboken, N. J.

10:20— 25. Techniques in the Automatic Control of Low-Temperature Vacuum Food Concentration
E. A. FEHLBERG, Director of Research, Pasco Packing Co., Dade City, Fla.
L. E. SLATER, Manager, Food Industry Division, Minneapolis Honeywell Regulator Co., Philadelphia, Pa.

10:35— 26. Some Consideration in Measuring the Life Expectancy of Baked Goods
C. F. DAVIS and R. K. HOWER, National Biscuit Co., New York, N. Y.

10:50— 27. Techniques for Estimating the Stability of Food Products—Active Dry Yeast
JOHN CRANE, H. K. STEELE and S. REDFERN, The Fleischmann Laboratories, Standard Brands, Inc., New York, N. Y.

11:05— 28. Laboratory Procedures for Determining Performance of Frozen Food Packages
A. M. MUNTER, C. H. BYRNE and K. G. DYKSTRA, Birds Eye Division, General Foods Corp., Albion, N. Y.

10:15— 37. Freezing Fish at Sea Investigations

TUESDAY MORNING

Section F—Parlors F and G

RECENT DEVELOPMENTS IN THE MEAT INDUSTRY

Chairman: H. R. KRAYBILL

9:00— Introductory Remarks

9:10— 29. The Quick Curing of Bacon
V. R. RUPP, Director of Research, Kingan & Co., Indianapolis, Ind.

9:35— 30. Increased Returns from By-Products in Meat Packing Operations
J. L. CARLSON, C. E. GROSS, K. A. HIRLINGER, J. B. LYNCH, R. W. RANSOM and P. L. TWEDT, John Morrell & Co., Ottumwa, Iowa

10:00— 31. The Effect of Ascorbate on Hemoglobin Oxidation and Meat Color
BETTY M. WATTS, Professor of Foods, Syracuse University, Syracuse, N. Y.

10:15— 32. Bacteriological Aspects of Pre-Packaged Meats
A. A. KRAFT and JOHN C. AYRES, Department of Bacteriology, Iowa State College, Ames, Iowa

10:30— 33. Prevention of Rancidity Development in Frozen Creamed Turkey
HANS LINEWEAVER, JOYCE H. ANDERSON and HELEN L. HANSON, Western Regional Research Laboratory, Albany, Calif.

TUESDAY MORNING

Section G—Panel Room

FISHERY TECHNOLOGY

Chairman: CARL R. FELLERS

9:00— Introductory Remarks

9:10— 34. Canning Little Tuna
NORMAN D. JARVIS, Fishery Technological Laboratory, U. S. Fish and Wildlife Service, College Park, Md.

9:35— 35. Preservation of Very Small Fish in the Philippine Islands
ARTHUR C. AVERY, U. S. Naval Supply Research and Development Facility, Naval Supply Depot, Bayonne, N. J.

10:00— 36. Frozen Atlantic Oyster Investigations
SAMUEL R. POTTINGER, U. S. Fish and Wildlife Service, Boston, Mass.

10:15— 37. Freezing Fish at Sea Investigations
JOSEPH F. PUNCOCHAR, U. S. Fish and Wildlife Service, Boston, Mass.

10:50— 38. Protein Denaturation in Frozen and Stored Fish
W. J. DYER, Atlantic Fisheries Experimental Station, Halifax, N. S.

11:15— 39. Trimethylamine Formation in Fish
DAVID W. ANDERSON, JR., and CARL R. FELLERS, Department of Food Technology, University of Massachusetts, Amherst, Mass.

TUESDAY AFTERNOON—JUNE 19

Section H—Ballroom

ACCEPTABILITY TESTING TECHNIQUES

Chairman: GEORGE GARNATZ

2:45— Introductory Remarks

2:55— 40. Evaluation and Mathematical Properties of Taste Discrimination Screening Tests Based on Triangular Items
S. HARRISON, N. H. ISHLER and E. LAUE, Central Laboratories, General Foods Corp., Hoboken, N. J.

3:20— 41. Binomial Systems and Organoleptic Analysis
ERNEST E. LOCKHART, Massachusetts Institute of Technology, Cambridge, Mass.

3:45— 42. Selection of Sensory Testing Panels
NORMAN F. GIRARDOT, DAVID R. PERYAM and RUTH SHAPIRO, Quartermaster Food and Container Institute, Chicago, Ill.

4:10— 43. Techniques Which Have Been Employed Successfully in Consumer Acceptance Testing
BEE ANGELL, Bee Angell and Associates, Chicago, Ill.

4:35— 44. The Consumer Angle — As Revealed by Newspaper Consumer Analyses
A. F. HALL, Manager, General Advertising, *Milwaukee Journal*, Milwaukee, Wis.

TUESDAY AFTERNOON

Section I—Gold Room, Manhattan Center

MILITARY SUBSISTENCE AND DEHYDRATED FOODS

Chairman: COL. R. A. ISKER

2:45— Introductory Remarks

2:55— 45. Relation of Time of Harvest and Area of Production to Yield, Quality and Acceptance of Dried Fruits. I. Prunes

JOHN KILBUCK, University of California, Berkeley, Calif.

3:10— 46. Microbiological Deterioration of Dried Fruits

E. M. MRAK, University of California, Berkeley, Calif.

3:35— 47. The Microbiology of Dehydrated Vegetables and Indices of Sanitation

REESE H. VAUGHN, University of California, Berkeley, Calif.

3:50— 48. Storage of Dehydrated Vegetables

R. R. LEGAULT, C. E. HENDEL and WILLIAM F. TALBURT, Western Regional Research Laboratory, Albany, Calif.

4:05— 49. How Research and Development Assists in Army Feeding

LT. COL. C. A. ROGERS, Chief of the Army Food Service, OQMG, Washington, D. C.

4:25— 50. Commissary Research for the U. S. Navy

ALLEN LEVENSON, U. S. Naval Supply Research and Development Facility, Naval Supply Depot, Bayonne, N. J.

4:35— 51. The Role of Food Industry in the Development of New Products for Naval Subsistence

LCDR J. A. CORRICK, JR., SC, USN, LENDAL H. KOTSCHEVAR and ARTHUR C. AVERY, U. S. Naval Supply Research and Development Facility, Naval Supply Depot, Bayonne, N. J.

4:50— 52. Evaluation of the Methyl Ester of Alpha Naphthalene Acetic Acid as a Sprout Inhibitor for Potatoes Under Armed Forces Conditions of Use

JOSEPH R. WAGNER, FRANCES HEMPHILL, MORRIS SIMON and BARBARA HEIBERG, Quartermaster Food and Container Institute, Chicago, Ill.

5:05— 53. Extending Shelf Life of Cocoa-Type Coatings for Use in Army Rations

JUSTIN J. ALIKONIS, Paul F. Beich Co., Bloomington, Ill.
KENNETH T. FARRELL, Quartermaster Food and Container Division, Chicago, Ill.

TUESDAY AFTERNOON

Section J—Panel Room

GENERAL PAPERS

Chairman: R. F. LIGHT

2:45— Introductory Remarks

2:50— 54. Factors Affecting the Stability of Color of Canned Ripe Olives

W. V. CRUESS, University of California, Berkeley, Calif.

3:05— 55. The Reaction Between Proteins and Reducing Sugars in the "Dry" State

C. H. LEA and R. S. HANNAN, University of Cambridge, Low Temperature Research Station, Cambridge, England

3:20— 56. Spoilage Bacteria in Tomato Products

L. S. WHITE, Ontario Research Foundation, Toronto, Canada

3:35— 57. Hydrolytic Action of *Pseudomonas fluorescens* on Fats

MORRIS L. GOLDMAN and MORTON M. RAYMAN, Quartermaster Food and Container Institute, Chicago, Ill.

3:50— 58. So You Have to Write Technical Reports

MARTIN S. PETERSON, Quartermaster Food and Container Institute, Chicago, Ill.

4:05— 59. Pasteurized Fresh Whole Pickles. I. Pasteurization Studies

W. B. ESSELEN, JR., E. E. ANDERSON, L. F. RUDER, JR. and I. J. PFLUG, University of Massachusetts, Amherst, Mass.

4:20— 60. Pasteurized Fresh Whole Pickles. II. Thermal Resistance of Microorganisms and Peroxidase

E. E. ANDERSON, L. F. RUDER, W. B. ESSELEN, JR., E. A. NEBESKY, and M. LABBEE, University of Massachusetts, Amherst, Mass.

4:35— 61. The Development of a New Process for Curing Coffee

WILLIAM R. JOHNSTON and H. ELLIOTT FOOTE, The Fleischmann Laboratories, Standard Brands, Inc., New York, N. Y.

4:50— 62. Relation of Ketchup Color to Tomato Color as Determined by the Hunter Instrument

ROBERT E. BUCK and RUTH A. SPARKS, H. J. Heinz Co., Pittsburgh, Pa.

5:05— 63. The Use of Modifiers in Chocolate

NELSON R. EASTON and LESTER R. BARTRON, Lehigh University, Bethlehem, Pa.

5:20— 64. The Effective Control of Mold Growth on Walls and Ceilings of Food Processing Plants

LLOYD G. HERMAN and CLYDE L. REED, Wilson & Co., Inc., Chicago, Ill.

5:35— 65. Sequestering and Vitamin C Destruction by Copper

ROY E. MORSE, Food Technology Laboratories, Monsanto Chemical Co., Anniston, Ala.

TUESDAY AFTERNOON

Section K—East Room

CITRUS FRUIT TECHNOLOGY

Chairman: J. L. HEID

2:45— Introductory Remarks

2:55— 66. Incidence and Significance of Microorganisms in Citrus

WEDNESDAY MORNING—JUNE 20

2:55— 66. Incidence and Significance of Microorganisms in Citrus Juices

L. W. FAVILLE and E. C. HILL, Citrus Experiment Station, University of Florida and Florida Citrus Commission, Lake Alfred, Fla.

3:10— 67. The Utilization of Citrus Fruit Processing Wastes. Microbiological Production of Riboflavin and Citric Acid from Citrus Molasses

ELMER L. GADEN, JR., DEMETRE N. PETSIAVAS and JOSEPH WINOKER, Columbia University, New York, N. Y.

3:25— 68. Gelation and Clarification in Concentrated Citrus Juices. I. Introduction and Present Status

F. W. WENZEL, A. H. ROUSE and E. L. MOORE, Citrus Experiment Station, University of Florida and Florida Citrus Commission, Lake Alfred, Fla.

3:40— 69. Gelation and Clarification in Concentrated Citrus Juices. II. Effect of Quantity and Type of Pulp in the Concentrate

R. W. OLSEN, R. L. HUGGART, DOROTHY M. ASBELL and C. D. ATKINS, Citrus Experiment Station, University of Florida and Florida Citrus Commission, Lake Alfred, Fla.

3:55— 70. Experimental Treatment of Citrus Waste Water

ROBERT R. MCNARY, RICHARD W. WOLFORD and VINCENT D. PATTON, Florida Citrus Commission, Citrus Experiment Station, Lake Alfred, Fla.

TUESDAY AFTERNOON

Section L—East Room

FLAVORS

Chairman: M. B. JACOBS

4:15— Introductory Remarks

4:20— 71. Fruit Flavors

DR. J. H. MCGLUMPHY, Van Ameringen-Haebler, Inc., Elizabeth, N. J.

4:40— 72. Preparation of Terpeneless Oils

MORRIS B. JACOBS, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

5:00— 73. The Effect on the Flavor of Strawberry Preserves Caused by Partial Replacement of Sucrose with Other Sweeteners

ROBERT L. SWAINE, Arthur D. Little, Inc., Cambridge, Mass.

WEDNESDAY MORNING—JUNE 20

Section M—Ballroom

LOW TEMPERATURE EVAPORATION OF FOODS

Chairman: D. B. HAND

9:00— Introductory Remarks

9:10— 74. An Evaporator for the Concentration of Citrus and Other Fruit Juices

C. D. ATKINS, Florida Citrus Commission, Citrus Experiment Station, Lake Alfred, Fla.

9:35— 75. Economic, Functional and Bacteriological Aspects of a Carrier-Howard Concentrator as Applied to Food Products

J. B. MERRILL, Sales Engineer, Carrier Corp., Syracuse, N. Y.

10:00— 76. Low Temperature Evaporation of Foods

JOSEPH A. CROSS, Mojonnier Bros. Co., Chicago, Ill.

10:25— 77. Low Temperature Evaporation of Food Products

LEWIS W. HULL and EARL W. FLOSDORF, F. J. Stokes Machine Co., Philadelphia, Pa.

10:50— 78. Low Temperature Evaporators

ALBERT W. ECKSTROM, Buflovak Equipment Division, Buffalo, N. Y.

11:15— 79. Comparison of Low-Temperature Evaporators

HUGH W. SCHWARZ, Minute Maid Corp., Plymouth, Fla.

WEDNESDAY MORNING

Section N—Gold Room, Manhattan Center

SANITATION

Chairman: B. L. OSER

9:00— Introductory Remarks

9:10— 80. Control of Sanitation in Food and Drug Plants

CHARLES A. HERRMANN, Chief, New York District, Food and Drug Administration, New York, N. Y.

9:35— 81. Development of Self-Inspection for Sanitation in Food Plants of New York City

JEROME B. TRICHTER, Assistant Commissioner, New York City Department of Health, New York, N. Y.

10:00— 82. Staphylococcus Food Poisoning

M. S. BERGDOLL, M. J. SURGALLA and G. M. DACK, The University of Chicago, Food Research Institute, Chicago, Ill.

CHEMICALS IN FOODS

Chairman: B. L. OSER

10:30— 83. Development of Guiding Principles for the Use of Chemical Additives in Foods

H. E. LONGENECKER, University of Pittsburgh, Pittsburgh, Pa.

10:55— 84. Pesticides Essential to Food Production

L. S. HITCHNER, National Agricultural Chemicals Association, Washington, D. C.

11:20— 85. Reflections on Gauging the Toxicity of Chemicals in Foods

B. L. OSER, Food Research Laboratories, Long Island City, N. Y.

WEDNESDAY MORNING

Section O—Parlors F and G

FOOD PRESERVATION

Chairman: BERNARD E. PROCTOR

9:00— Introductory Remarks

9:10— 86. The Application of "End-Over-End" Agitation to the Heating and Cooling of Canned Food Products

WELD CONLEY, LAURENCE KAAP, LEO SCHUHMANN and JAMES RETZER, Chain Belt Company, Milwaukee, Wis.

9:30— 87. Paper withdrawn after completion of program.

9:50— 88. Food Preservation with Antibiotics: The Problem of Proof

E. J. CAMERON and C. W. BOHRER, National Canners Association, Washington, D. C.

10:10— 89. Preservation of Milk by Radiation

ELMER L. GADEN, JR., ERNEST J. HENLEY and VINCENT P. COLLINS, Columbia University, New York, N. Y.

10:25— 90. Food Processing with Ionizing Radiations

BERNARD E. PROCTOR and SAMUEL A. GOLDBLITH, Massachusetts Institute of Technology, Cambridge, Mass.

10:45— 91. Thermal Destruction of Cameron's Putrefactive Anaerobe 3679 in Food Substrates

HOWARD REYNOLDS, ARTHUR M. KAPLAN, FRANCIS E. SPENCER and HAROLD LICHTENSTEIN, Bureau of Human Nutrition and Home Economics, Agricultural Research Administration, U. S. Department of Agriculture, Washington, D. C.

11:00— 92. Factors Influencing the Stability of Thiamine During Heat Sterilization

D. G. HEBERLEIN, L. R. PTAK, G. H. BENDIX and L. E. CLIFCORN, Continental Can Co., Inc., Chicago, Ill.

11:20— 93. An Automatically-Controlled Five-Cabinet System for Food Stability Studies

S. BARER, N. H. CEAGLSKE and W. F. GEDDES, University of Minnesota, Minneapolis, Minn.

WEDNESDAY AFTERNOON—JUNE 20

Section P—Ballroom

INSTRUMENTATION AND CONTROL METHODS IN FOOD PROCESSING—SYMPOSIUM

Chairman: ALBERT L. ELDER

2:30— Introductory Remarks

2:40— 94. Instrumentation and Research at the National Bureau of Standards

WILLIAM A. WILDHACK, Chief, Office of Basic Instrumentation, National Bureau of Standards, Washington, D. C.

3:05— 95. Physics and Special Instrumentation

NELSON GILDERSLEEVE, Meter and Instrument Sales Divisions, General Electric Co., West Lynn, Mass.

3:30— 96. Utilization of Instrumentation in the Wet Milling Industry

H. C. FROST, Corn Products Refining Co., Chicago, Ill.

3:55— 97. Discussion of Previous Papers

Moderator, JOHN R. BOWMAN, Mellon Institute of Industrial Research, Pittsburgh, Pa.

4:30— 98. Measurement and Control of Color in Canned Tomato Juice

W. B. ROBINSON, J. R. RANSFORD and D. B. HAND, New York State Agricultural Experiment Station, Geneva, N. Y.

4:45— 99. Measurement of the Color of Green Beans by Reflection

T. W. KETHLEY, W. B. COWN and F. BELLINGER, Georgia Institute of Technology, Atlanta, Ga.

5.00—100. Mathematical Analysis of the Reflected Color of Green Beans

T. W. KETHLEY, W. B. COWN and F. BELLINGER, Georgia Institute of Technology, Atlanta, Ga.

WEDNESDAY AFTERNOON

Section Q—Gold Room, Manhattan Center

FROZEN FOODS

Chairman: E. H. WIEGAND

2:30— Introductory Remarks

2:40—101. Objective Measurement in Quality Control of Frozen Foods
J. L. HEID, Golden Citrus Juices, Inc., Fullerton, Calif.

3:05—102. Objective Testing of Vegetables
AMIHUD KRAMER, Department of Horticulture, University of Maryland, College Park, Md.

3:30—103. An Objective Method for Measuring the Effect of Freezing Rate on Asparagus
F. A. LEE, New York State Agricultural Experiment Station, Geneva, N. Y.

3:45—104. Effect of Processing Procedures on Quality of Frozen Whole Kernel Sweet Corn
F. E. LINDQUIST, W. C. DIETRICH and M. M. BOGGS, Western Regional Research Laboratory, Albany, Calif.

4:00—105. Browning of Frozen Vegetables, Particularly Okra
J. G. WOODROOF and ETHYL SHELOR, Agricultural Experiment Station, University of Georgia, Experiment, Ga.

4:15—106. Effects of Freezing on Tenderness of Beef from Different Muscles and from Animals of Different Ages
RICHARD L. HINER, Bureau of Animal Industry, Agricultural Research Division, U. S. Department of Agriculture, Beltsville, Md.

4:30—107. A Survey of Processing Methods Used in Frozen Food Locker Plants
C. F. DUNKER and O. G. HANKINS, Bureau of Animal Industry, Agricultural Research Administration, U. S. Department of Agriculture, Beltsville, Md.

4:50—108. Preparation of Stable Frozen Sauces and Gravies
HELEN L. HANSON, AGNES CAMPBELL and HANS LINEWEAVER, Western Regional Research Laboratory, Albany, Calif.

5:05—109. Influence of Storage Conditions on Frozen and Canned Apple Juice Concentrates
C. C. NIMMO, L. H. WALKER and VIRGINIA SEAMANS, Western Regional Research Laboratory, Albany, Calif.

WEDNESDAY AFTERNOON

Section R—Parlors F and G

NEW FOOD PRODUCTS

Chairman: L. E. CLIFCORN

General Problems

2:30— Introductory Remarks

2:35—110. Consumer Trends in New Food Products for Homemakers
A. A. SCHAAL, Good Housekeeping Bureau, New York, N. Y.

2:55—111. New Foods for Institutional Use
PAUL P. LOGAN, National Restaurant Association, Chicago, Ill.

3:15—112. New Food Products Needed by the Armed Forces
HOWARD D. LIGHTBODY, Quartermaster Food and Container Institute, Chicago, Ill.

3:35—113. Dietetic Foods
JAMES D. WILSON, Council on Foods and Nutrition, American Medical Association, Chicago, Ill.

3:55—114. Some Practical Problems in the Introduction of New Food Products
FRANKLIN C. BING, Chicago, Ill.

New Developments

4:15—115. New Developments in Meat Products
H. R. KRAYBILL, American Meat Institute Foundation, Chicago, Ill.

4:21—116. Partially Baked Products
THOMAS FREER, General Mills, Inc., Minneapolis, Minn.

4:39—117. New Dairy Products
LLOYD K. RIGGS, National Dairy Research Laboratories, Inc., Oakdale, L. I.

4:51—118. Recent Activities in Candy Research
PHILIP P. GOTT, National Confectioners' Association, Chicago, Ill.

5:02—119. What's New in Frozen Concentrates
G. E. HILBERT, Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture, Washington, D. C.

5:14—120. New Products from California Cling Peaches
W. V. CRUESS, R. O'NEAL and W. RIVERA, University of California, Berkeley, Calif.

1. PRODUCTION PROGRESS IN THE TIN PLATE INDUSTRY

R. B. MENEILLY, United States Steel Corp., Pittsburgh, Pa.

Only two decades ago the first visions of a new continuous process for rolling steel to tin mill gages and widths appeared. A few years later, 1937, new tinning methods were developed. The tin plate, can making and canning industries carefully analyzed both processes and looked to the future. Today we look back at the complete revolution in processing methods and improved quality. Not only is it difficult to locate a single piece of equipment in any tin plate mill today which was in use twenty years ago, but practically all machinery and equipment are totally different. Only the steel and the tin have any resemblance to the old tin mill and, even here, the changes in processing appear to have changed the basic materials. In other words, the industry has been completely rebuilt from new foundations and on new principles.

2. SIGNIFICANCE OF CONTINUOUS PRODUCTION METHODS IN THE MANUFACTURE OF TIN PLATE

E. D. MARTIN, Inland Steel Company, East Chicago, Ill.

The revolution in manufacturing steel by continuous processing in strip form had its impact on the manufacture of tin plate. Continuous processing and better control of the operation has made a much superior and relatively cheaper product.

Steel in the form of hot slabs is continuously rolled in hot strip mills to coils each of which weighs many tons. After continuous pickling to remove the surface oxide these coils are rolled cold at speeds up to 6,000 feet a minute substantially to the finish thickness of tin plate. These mills consist of several stands in tandem between the rolls of which the steel is progressively reduced in thickness.

The cold rolling hardens the steel by its compressing and elongation action and leaves it coated with oil used as a lubricant in rolling. It is necessary then to remove the oil by washing. This is done in continuous lines operating at high speeds. The washed steel is softened by annealing in coil form in "box annealing" or, as recently developed, continuously at speeds up to 800 feet a minute. To form the smooth cylindrical bodies of cans the softened steel must be lightly rolled cold in "temper" mills.

The steel base is now ready for the tinning operations by the old hot dipped method after shearing and side trimming into sheets or as coils in the more recent electrolytic methods. Pickling in acid to prepare the surface precedes the tinning, and in the case of the electrolytic method of coating with tin, washing may also be done as a preparatory step. Electrodeposited tin is usually melted "flow brightened" or "fused" to impart certain qualities and to make the surface appearance more reflective and brilliant. Finishing treatments develop particular qualities of the surface which are important in subsequent processing by the can maker.

After careful inspection and "assorting" the finished product is well packaged and shipped to the producers of cans. "Black plate" or steel in the form obtained before tinning is another product while "terne plate" differs by being given a coating of alloyed lead and tin.

The manufacture of tin mill products in the United States is an important business which has demanded a tremendous investment by the steel industry. Producing now at the rate of 5,300,000 tons a year of tin mill products, the United States used for this purpose more steel than is produced for all uses by any other country except Russia, the United Kingdom, France, and Germany.

3. CORROSION FACTORS RELATED TO THE USE OF TIN PLATE FOR FOOD CONTAINERS

R. R. HARTWELL, Research Department, American Can Company, Maywood, Ill.

The internal corrosion of tin plate containers is controlled by two equally important groups of factors, one of which relates to the product in the container. The second group, pertaining to container construction and to tin plate in particular, is the usual commercial means of controlling container corrosion. Research of the past twenty years and the correlated developments in the tin plate industry have made possible containers with improved corrosion performance, and without these advances only a minor degree of tin conservation would be possible.

The most important characteristics of tin plate from the corrosion viewpoint is the relatively inert behavior of tin toward most food products, combined with the ability to furnish electrochemical protection to the steel base, and many factors concerning the steel and tin coatings are capable of influencing the extent of this protection. There are a number of widely held beliefs in regard to corrosion of tin plate which have little basis in facts.

4. EFFECT OF PROGRESS IN TIN PLATE MANUFACTURE ON THE USE OF TIN PLATE FOR CANS FOR FOODS

A. E. STEVENSON, Continental Can Company, Inc., Chicago, Ill.

The plate requirements of products packed in metal containers vary widely depending on the characteristics of the individual products. Progress in the manufacture of tin plate has enabled the can manufacturer to produce containers meeting these individual requirements. From the standpoint of weight of tin coating on the plate, the requirement may vary from 0.25 lb. tin coating to 1.50 lbs. or higher. This range has become available through the development of electrolytic tin plate, and the use of plate with the lower weights of tin coating has enabled the can manufacturing industry to operate at high volume during periods of restriction in the use of tin and still produce satisfactory containers. Comprehensive research and testing programs carried out by can company research laboratories have permitted the extension of the use of electrolytic plate containers to an increasingly greater number of products. This is reflected in the growth of electrolytic plate production from 3.0 per cent of the total tin plate production in 1942 to 59.8 per cent of the total in 1950. The average amount of tin per base box of plate used in the manufacture of cans has dropped from 1.50 lbs. in 1940 to less than 0.80 lb. in 1950. A further decrease will result in 1951 due to the much greater use of plate with a tin coating of 0.25 lb. per base box. While relaxation of government restrictions imposed in 1951 may result in the use of heavier coated plate for cans for some products, the average amount of tin used per base box of plate in the future is not likely to exceed that for 1950 and is more likely to be lower.

5. TEMPERATURES NEEDED FOR THE TRANSPORT OF FRUITS AND VEGETABLES

W. T. PENTZER, Bureau of Plant Industry, U. S. Department of Agriculture, Beltsville, Md.

All fruits and vegetables do not respond alike to low temperature storage and transport. Some commodities such as unripe tomatoes, sweetpotatoes, some citrus fruits, pumpkins, squash, cucumbers, eggplant, lemons, limes, grapefruit, unripe pineapple, olives, avocadoes, bananas and other tropical or subtropical fruits do

not tolerate temperatures as low as 32° even for short periods and some are injured by temperatures of 40° or 50°F. Abnormalities develop such as skin pitting in citrus fruits, ripening may be impaired or prevented, and susceptibility to decay may be increased. Different varieties of the same fruit may require different temperatures for long storage, and the climatic condition under which the fruit is grown has a bearing on its response to low temperature in some cases. There are many fruits and vegetables, however, that are benefited by temperatures as near to their freezing temperature as is safe to use. Most varieties of apples and pears fall into this category as do cabbage, carrots, onions, grapes, plums, peaches, berries and other fruits and vegetables.

6. MECHANICAL REFRIGERATION IN THE TRANSPORTATION OF PERISHABLE FOOD

WALTER H. REDIT, Division of Fruits and Vegetable Crops and Diseases, BPISAE, U. S. D. A., Beltsville, Md.

Mechanical refrigeration in the rail transportation of perishable foods is an accomplished fact with its most recent developments for refrigerator cars. The phenomenal growth of the frozen foods industry, which desires transit temperatures lower than that obtained with ice and salt, has accelerated this development, with the new rail equipment being used chiefly for these products. This equipment, developed by one of the refrigerator car lines, is powered by both gasoline and diesel-electric systems of similar design. Tests have been conducted on rail equipment with frozen foods which show the importance of adequate air circulation, loading, refrigeration capacity and maintenance. Other units for pre-cooling, refrigerating, heating and humidifying other perishables are now on the drawing boards and should soon be ready for testing.

7. THE MARINE TRANSPORTATION OF PERISHABLES

L. L. WESTLING, Matson Navigation Company, San Francisco, Calif.

The influences of the factors of source, processing, packing and land transportation upon successful delivery of cargo are discussed. The procedure of receiving and shipside inspection will be described, together with the problems facing terminal or ship operators and the protective or corrective measures.

Methods of handling and stowage will be covered, and the differences between shoreside and ship cold storage will be pointed out. Types of ships and their refrigerator arrangements will be touched upon.

Methods of distribution of refrigeration will be treated and their merits and faults mentioned. The influence of temperatures and humidities will also be discussed. The shipment of perishables without benefit of refrigeration will be referred to.

8. THE TRUCK TRANSPORTATION OF PERISHABLES

T. G. LUMBRA, Champlain Valley Fruit Co., Inc., Burlington, Vt.

The discussion will cover the following:

1. The trucks of the past, present, and foreseeable future.
2. The various types of truck refrigeration, insulation, and ventilation of cargo.
3. Running schedules to various important markets from principal producing areas, and difficulties presently encountered enroute.
4. The use of recording thermometers to guarantee the receiver constant proper temperature enroute.
5. An explanation of the research being conducted at terminal markets on condition of cargo on arrival, and condition of equipment.
6. Explanation of the research being undertaken with the government regarding the advisability of daily recording and reporting of perishable shipments as they cross the originating state's line.

9. TRANSPORTATION OF FROZEN PERISHABLES

HAROLD C. EMERSON, Cumberland Warehouse Corporation, Bridgeton, N. J.

The discussion will cover the following:

1. The need for "freezer transportation"
   (a) The scope, growth, and purpose of quick frozen goods will be gone over lightly together with areas of production and consumption.
2. The place of "freezer transportation" in the economic chain from farmer to consumer.
3. Methods of transportation, costs, state regulations, etc.
4. The challenge to the Institute of Food Technologists.

10. PRESENT STATUS OF THE THEORY OF BREAD STALING

W. G. BECHTEL and D. F. MEISNER, American Institute of Baking, Chicago, Ill.

Currently, those changes which occur in the starch component of bread on aging are considered to be of major importance in the explanation of the bread staling phenomenon. There is, however, serious disagreement as to the validity of the methods employed in measuring these changes, or other changes which occur in bread associated with these changes in starch, and, to their significance. Since staling is of economic importance because of consumer judgment, organoleptic testing appears to have fundamental significance. There is need, however, for laboratory tests (physical or chemical) which can be applied and analyzed rapidly. These various methods of measuring staling rate, such as compressibility, firmness, soluble starch, swelling power, farinograph consistency, crumbliness and organoleptic evaluation, are discussed with interpretations based upon laboratory data. Certain of these data are of special significance as they show that soluble starch, whether it be determined as total soluble carbohydrate, soluble amylose or soluble amylopectin, cannot be related to the staling process. The role of starch in the bread staling phenomenon is discussed.

11. LIGHT DESTRUCTION OF RIBOFLAVIN IN BAKERY PRODUCTS

H. W. LOY, JR., J. F. HAGGERTY and E. L. COMBS, Division of Nutrition, Food and Drug Administration, Federal Security Agency, Washington, D. C.

The stability of riboflavin to heat over a wide range of pH has been established, but it is well recognized that this vitamin is quite labile to light. In routine analysis of enriched bakery products losses of riboflavin were observed that were not the result of the baking process. To determine what are critical factors in preparation

of samples for analysis and to measure possible destructive effects of light that might occur in retail handling of bakery products, the following studies were conducted.

Several types of bakery products were exposed to artificial light of the laboratory and to sunlight for periods of one to seven days, and the riboflavin content was measured at intervals. Important losses of riboflavin, greater than expected, were found to occur in sliced enriched bread and in partially baked rolls exposed to sunlight through window glass in January. In the more extreme conditions losses were found to exceed 50%. Bread wrapped in wax paper showed measurable loss after seven days. Cellophane wrapping offered only slight protection from light destruction in partially baked rolls. Artificial light caused measurable loss in three days and important losses in longer periods in unwrapped bread or rolls as well as in cellophane wrapped products. Enriched flour, similarly exposed to light, showed no measurable change. Thiamine and niacin were also determined in these samples and were found to be unaffected. The significance of these results will be discussed with suggestions for proper handling of analytical samples of bakery products.

12. THE BULK TRANSPORTATION AND HANDLING OF FLOUR

PAUL TALMEY, The Great American Transportation Company, Chicago, Ill.

For many years there has been considerable interest in the transportation of flour in bulk. The first car for this purpose was designed by the Great American Transportation Corp. in the early thirties. After the war interest in its application was greatly increased and efforts reviewed to solve the economical, practical and technical problems involved. The Great American Transportation Corp., the Fuller Company—manufacturers of pneumatic equipment—and the National Biscuit Company cooperated in experiments designed to explore the practical application of the bulk transportation of flour.

The present Trans Flo car of all welded steel construction overcomes the danger of contamination that is always present during transportation and of condensation moisture within the car. At present there are 24 Trans Flo cars in successful operation. The Fuller pneumatic system has been adopted for the conveying of flour from the mill stream to the car and from the car to storage bins in the bakery. Insulated and heated tanks erected in the open are suggested for the storage of flour in bulk for efficient utilization of the Fuller system for the unloading of the car and distribution of the flour in the bakery.

For smaller bakeries the use of "tote boxes" is suggested for trucking the flour from the mill or from the bulk storage and distribution center as needed. The flour would be transported from the mill to the storage center in Trans Flo cars.

With the solution of the mechanical problems of bulk transportation and handling of flour, a virtually 100% sanitary method is available at an important saving in cost.

13. RADIOGRAPHY APPLIED TO GRAIN AND SEEDS

MAX MILNER, M. R. LEE and ROBERT KATZ, Department of Milling Industry and Department of Physics, Kansas State College, Manhattan, Kan.

For the detection of hidden infestation in grain, low energy radiation from a cobalt-target beryllium-window x-ray tube was found ideal. The presence of a minimum amount of extraneous material between the grain specimen and film, as well as the use of special x-ray film, facilitated the production of detailed radiographs showing clearly internal insect infestation at all stages of development. The utility of the technique for the inspection of wheat, corn, beans, etc. will be demonstrated by means of slides made up from original radiographs.

14. THE MODERN CONCEPT OF FOOD PACKAGING

A. S. LEVINE and I. S. FAGERSON, Department of Food Technology, University of Massachusetts, Amherst, Mass.

Food packaging should no longer be a hit or miss proposition. A careful evaluation of the packaging requirements of the food product coupled with an understanding of the characteristics of the packaging materials available will do much to improve the overall packaging situation. Many fine objective tests have been developed for both the foods and the packaging materials to indicate the requirements and suitability so that the best package for each product will be evolved.

An examination should be made of the food product for critical moisture content, moisture equilibrium, fat content, abrasiveness, density, susceptibility to insect infestation, damage by light, gas evolution, etc.

The packaging materials should be selected after a careful consideration of their ability to protect the product during its normal expected shelf life plus a safety factor against those hazards to which the product is particularly sensitive. Tests for strength, greaseproofness, moisture vapor transmission, gas transmission, etc., should be conducted on the packaging material not only for original selection but also as a quality control measure as long as such a material is employed.

The end result should be a culmination of an intelligent study of such factors as product requirements, functional properties, eye appeal and economics.

15. METHOD FOR MEASURING GAS TIGHTNESS OF CROWN CLOSURES

V. C. GUSE, Bond Crown and Cork Co., a subsidiary of Continental Can Co., Inc.

A new laboratory method and apparatus have been devised for the determination of the sealing efficiencies of crown closures. The method permits continuous collection and accurate measurement of gas leakage from crowned bottles. It has several advantages over the usual pressure testing technic, particularly in time savings and reliability because the gas leakage is measured directly at any desired time interval without destruction of the crown. Conventional pressure testing gives an indirect measurement of the gas leakage, requires considerable time and ruins the individual sample; thereby, introducing a crown and bottle variable.

The apparatus consists essentially of a gas collection tube carefully sealed over the top of a crowned bottle and connected to a leveling bulb. Each assembled unit is stored under the desired conditions and periodic readings of the escaping gas trapped above a suitable liquid, such as glycerol, are made. Rates of leakage as well as total leakage for the duration of each test can be determined.

With slight modifications in apparatus this convenient method can conceivably be applied to the testing of other type closures familiar to the food technologist.

16. PRINCIPLES OF NITROGEN PACKING IN FLEXIBLE FILMS

W. S. WALKER, Linde Air Products Company, a Division of Union Carbide and Carbon Corporation, New York, N. Y.

Defines and discusses principal requirements for effective nitrogen-packing of foods in film containers: (1) Exclusion of oxygen from food product; (2) Exclusion of oxygen from container, and (3) Use of a film with low oxygen permeability for oxygen exclusion during storage.

Methods used to check tightness of seals for nitrogen packaging are discussed.

17. ADHESIVES IN FOOD PACKAGING

L. E. SIMERL, Marathon Corporation, Menasha, Wis.

The problems of obtaining adhesives for highly specialized products, in an expanding field, are discussed. New products require more stringent specifications in food packaging manufacture, and very close cooperation with adhesive suppliers is necessary.

Any given new product is first fully evaluated in the laboratory. The criterion of any adhesive is fiber pull, where paper is involved, although other requirements include freedom from toxicity and odor, limited setting time, behavior on commercial gluing equipment, mileage and finally cost. Testing of the bond produced includes long term storage tests at accelerated conditions, ranging from zero F. to 100°F.-90% relative humidity and 100°F.-20% relative humidity.

Following the laboratory stage, the adhesive is usually evaluated on an experimental gluer, a variable speed machine, designed and built in our own shop, which also applies films such as acetate and cellophane to board surfaces. Changes in viscosity, tendency to skin, loss of solvent, and other changes due to continued operation are noted without interference with commercial equipment.

The final stage of testing is a series of runs on commercial equipment. This includes data and tolerances on solids, solvent, viscosity, freedom from taste, odor and toxicity, bond strength and stability, and includes packaging and shipping instructions. This last is primarily for resin emulsions, where a minimum temperature of 45° is specified in order to prevent freezing in winter. This system has been very successful in operation.

Considerable educational work has been necessary with plant supervision and operators, but reduction in complaints has far offset any costs. Several unsolved technical problems will be covered, including current material shortage difficulties.

18. A NEW GRAPHICAL INTERPOLATION METHOD FOR OBTAINING HUMIDITY EQUILIBRIUM DATA, WTH SPECIAL REFERENCE TO ITS ROLE IN FOOD PACKAGING STUDIES

ARTHUR H. LANDROCK and BERNARD E. PROCTOR, Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Mass.

This paper points out the need for careful study of the rate and the degree of moisture gain or loss in foods and food products in determining packaging requirements. A discussion of the terminology used in this phase of packaging technology affords a useful background of information for those contemplating work in this field. A brief description is given of a new graphical interpolation method of measuring humidity equilibria. The specific advantages and disadvantages of the method are discussed, and recommendations made as to application of the method for particular types of food products.

19. THE TRANSMISSION OF ORGANIC VAPORS THROUGH PACKAGING MATERIALS

T. J. MULDOON and F. J. SYLVESTER, General Foods Corporation, Hoboken, N. J.

Odors are a class of organic chemical compounds. A procedure used to measure their transmission rate through packaging films must either be adaptable to any compound or else must use one compound as being representative of all odors. The present method, based on the latter assumption, uses methyl furoate as the organic vapor, not because it is a common odor but because it has relatively high vapor pressure and is easily measured. Also its molecular configuration is similar to a number of familiar odors.

Coating glassine and sulphite sheets with 5 lb. wax per ream has reduced the organic vapor transmission rate to one-fortieth of the uncoated value.

Important use of this test is to ascertain packaging materials that will vent odors, yet act as a barrier to water vapor transfer.

20. IMPACT FATIGUE — A METHOD FOR PREDICTING BAG STRENGTH

T. J. MULDOON and R. DE S. COUCH, General Foods Corporation, Hoboken, N. J.

The impact fatigue test measures the ability of a sheet of paper to withstand repeated impacts. It has been found that the measurement of this property in paper correlates fairly well with the results of drop tests run on filled paper bags.

A large percentage of the products sold in this country are packaged in paper bags. There are many tests used to evaluate paper used to form bags, but unfortunately they do not predict with any degree of accuracy the performance that can be expected of the bag after it is filled with the product. The impact fatigue test appears to predict with fair accuracy the performance that may be expected of a bag made from paper.

The impacts are applied by allowing metal balls to drop from a predetermined height onto a rigidly held piece of paper. The number of balls required to fracture the paper is used as an indication of the impact fatigue strength. The higher the number of impacts before breakage the better the performance that can be expected of the bag.

21. STATISTICAL METHODS IN QUALITY CONTROL

GRANT WERNIMONT, Color Control Department, Eastman Kodak Company, Rochester, N. Y.

Technology appears in any field of human activity as soon as science and experimental methods begin to replace tradition and empirical methods. It has been easier to apply the experimental method in some fields than in others, depending somewhat on how closely the activities are related to the physical sciences. One reason for this may well be the fact that experimental measurements can be made in the physical sciences with less uncertainty than they can be made in most other fields.

Modern statistical methods are making it possible to design and interpret experimental work so that valid conclusions can be drawn from results obtained under much less closely controlled conditions than have been used in the physical sciences. It thus becomes possible to apply the methods of experimental science in fields of technology, such as quality control, which are not so closely associated with the physical sciences.

The correct interpretation of any experiment depends primarily upon whether or not the design permits a logical analysis of the results. It is therefore always desirable to design experiments along lines which are appropriate for statistical analysis. Four examples of such experiments are given.

The first example shows how a simple control chart for yes-no data was used to interpret routine production control records. The second example illustrates how control charts for variable measurements have been used to study the results

of inter-laboratory test programs. The third example is a factorial type of experiment which was used to find reasons why incoming raw material was not conforming to specifications set up for it. The final example illustrates the experimental design which is appropriate for the study of relationships between various measurements made on a production basis.

22. STATISTICAL QUALITY CONTROL OF FOOD PLANT PROCESSING

FRANK V. KENNEY, P. Ballantine & Sons, Newark, N. J.

This paper is intended to show the method of approach in controlling a typical food process using statistical quality control techniques.

In it, factors influencing the decision to use control charts are developed. This is followed by explanation of the method used in making the type of chart best suiting the purpose.

Included at this point are mention of factors causing normal data variation.

Where trouble is shown on the chart, it is explained, together with means of correlating this trouble with probable causes.

Methods of histogram analysis of data gathered in investigation of the problem are shown, together with conclusions drawn.

Finally, the chart shows effect of return to normalcy.

23. INSTRUMENTS FOR OBJECTIVE MEASUREMENT OF QUALITY CONTROL FACTORS IN PROCESSED FOOD PRODUCTS

B. W. CLARKE, The Crosse & Blackwell Company, Baltimore, Md.

There is a need in quality control procedures for instruments for measuring or recording the "appetite appeal" factors of processed foods. Instruments for this purpose should be inexpensive, rugged, and easy to operate and maintain under factory (not laboratory), conditions, and should be multi-purpose instruments of general acceptability.

A definite distinction must be recognized between the concepts of quality *control*, quality *measurement*, and quality *inspection*. Quality control should be preventive, not diagnostic. Instruments for quality control should give results which will enable the properties of the finished product to be predicted from tests made at an early stage in the process of manufacture.

The use of refractometers and pH meters has been generally adopted in quality control of preserve manufacturing, tomato products manufacturing, pickle processing, canning of specialty products, and other food processing operations, as these instruments fulfill the requirements for "preventive quality control" as outlined above.

Suitable instruments are lacking for measuring the consistency of non-homogenous processed food products such as tomato catsup or canned soups, or even homogenous products such as fruit jellies. A number of instruments for recording the viscosity or consistency of tomato catsup have been suggested, all of which have some disadvantages. For fruit jellies, various methods are available for determining jelly strength, based on methods used for pectin grading, none of which is entirely satisfactory.

With these products, there is no general agreement as to instruments best suited for quality *inspection*, and still less agreement as to the instruments to be used for effective quality *control*.

No instruments have been generally accepted in the food processing industries as suitable for measuring the texture of apples, peaches, berries, cucumbers, and many other fruits and vegetables, either as harvested, or at various stages of the processing operation, although special purpose instruments have been adopted for use with peas, corn, and asparagus.

There has been considerable work in the past few years on methods and equipment for color measurement in food products, which give satisfactory results from the point of view of quality inspection and research, but the instruments available, have not yet been developed to fulfill the requirements for use as quality control instruments.

It is suggested that the I.F.T. should consider the problem of stimulating and coordinating cooperative work with instrument manufacturers and food processors leading to the design and adoption of improved equipment for use in quality control and inspection of processed foods.

24. COLOR MEASUREMENT IN QUALITY CONTROL OF FOODS

C. C. SUTTON, R. C. AMBLER and D. ARKIN, Central Laboratories, General Foods Corporation, Hoboken, N. J.

Food colors are measured for two purposes, first, to serve as an index of appearance to the customer and second, to serve as an index of some other quality, such as the ripeness of a fruit. When color is to be used as an index of appearance, it is important that the particle size distribution, degree of packing, and wetness of the product and other factors which affect appearance be the same at the time of measurement as they will be when the consumer sees the product. On the other hand, when color is to be used as an index of some other quality, it is important that the particle size distribution, wetness and packing be adjusted to have minimum effect on the readings regardless of their effect on the appearance of the product. The procedure to be used for each type of measurement is described step by step.

25. TECHNIQUES IN THE AUTOMATIC CONTROL OF LOW-TEMPERATURE VACUUM FOOD CONCENTRATION

E. A. FEHLBERG, Pasco Packing Co., Dade City, Fla.

and

L. E. SLATER, Brown Instruments Division, Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.

Vacuum concentration of foodstuffs becomes economically successful only when the process is continuous and well balanced. An integration of automatic controls into a low-temperature evaporating system was studied, the objective being an uninterrupted, unsupervised process supplying a consistent product at maximum output. As a result of these studies, a control system, including especially designed components, was designed which would theoretically meet the dynamics and special requirements of this process.

The results of a season of processing with these controls indicates the feasibility of completely automatic evaporator operation. Particular emphasis is paid in this paper to the techniques which were employed to get an optimum performance from the control system.

26. SOME CONSIDERATION IN MEASURING THE LIFE EXPECTANCY OF BAKED GOODS

C. F. DAVIS and R. K. HOWER, National Biscuit Company, New York, N.Y.

The Schaal Oven test has many advantages in measuring the processing and ingredient factors affecting the fat stability in baked goods. A scientific investigation of shelf-life stability of biscuits and crackers presents many difficulties. A satisfactory correlation between Schaal Oven and shelf-life stability tests was not obtained. This was attributed principally to inability to obtain definite endpoints in shelf-life tests.

27. TECHNIQUES FOR ESTIMATING THE STABILITY OF FOOD PRODUCTS—ACTIVE DRY YEAST

JOHN CRANE, H. K. STEELE, S. REDFERN, The Fleischmann Laboratories, Standard Brands, Inc., New York, N. Y.

The factors affecting the life expectancy of food products vary widely, and are dependent on the character and properties of the food product in question. Food products run the complete gamut of sensitivity to changes, from the highly stable products such as sugar, to the highly perishable products such as fresh milk. Food products, therefore, may need protection against changes in moisture content, oxidation, bacterial contamination, loss of volatile flavor and aroma constituents, browning reaction, enzymic changes, etc., in order to extend their life expectancy.

In an investigation of the life expectancy for any given food product, laboratory controlled tests are the first step. These tests must be so devised that the results obtained correlate with those found when the product is exposed to the conditions encountered during the distribution and merchandising of the product.

The authors will limit their discussion of the problems encountered in determining life expectancy of food products to a study of the factors applicable to consumer active dry yeast. This was selected as illustrative material for our discussion of methods, since this rather unique food, although a dry product, is viable, and in order to preserve the functional activity of the product, viability of the cells must be preserved. The three most important factors affecting the life expectancy of active dry yeast are changes in moisture content, the availability of oxygen to the product, and the temperature to which the product is exposed.

The instruments applied to this problem, and the techniques developed will be discussed.

28. LABORATORY PROCEDURES FOR DETERMINING PERFORMANCE OF FROZEN FOOD PACKAGES

A. M. MUNTER, C. H. BYRNE and K. G. DYKSTRA, Birds Eye Division, General Foods Corporation, Albion, N. Y.

Containers for frozen foods are more or less in a class by themselves in their requirements of construction, resistance to moisture vapor transmission, etc. Since all frozen foods are, or should be, stored and handled at temperatures of 0°F. or below, the performance characteristics of packaging materials must be studied at these temperatures. For example, the moisture vapor transmission characteristics of packaging materials vary considerably with temperature. A further requirement is that the behavior of packaging materials be studied as the whole package. A method has been developed for the rapid determination of moisture vapor transmission characteristics of whole packages in a relatively short space of time. Through experience of several years, this has been related to performance of packages under normal storage and handling conditions. It is suggested that maximum permissible limits for moisture vapor transmission be established.

29. THE QUICK CURING OF BACON

V. R. RUPP, Kingan & Company

The meat packing industry has devoted much effort toward finding quicker ways to cure meat. Space savings, capital savings, and better control of inventories, have made this objective very desirable. Artery pumping has reduced the time required to cure hams and shoulders to a few days. Bacon bellies remained the last major pork cut requiring several weeks' curing time.

By injecting small amounts of concentrated curing pickle into bacon bellies with a hypodermic needle and according to an experimentally determined pattern, it was demonstrated that a satisfactory cure could be obtained in 48 hours. On the basis of these experiments a multiple-needle machine was eventually developed. With this machine the bacon belly is placed on a conveyor which automatically positions it for pumping; the needles pierce the belly, a predetermined amount of pickle is injected, the belly is removed from the needles, and conveyed to a truck.

Two operators, one to place the bellies on the conveyor and one to remove them, can pump up to 5,000 pounds per hour with this machine. The overall saving in labor is about 25%. The curing time is reduced to 48 hours and a substantial saving made in capital, space, and equipment.

Consumer tests show the quick cured bacon to be as acceptable as the long cure.

30. INCREASED RETURNS FROM BY-PRODUCTS IN MEAT PACKING OPERATIONS

J. L. CARLSON, C. E. GROSS, K. A. HIRLINGER, J. B. LYNCH, R. W. RANSOM and P. L. TWEDT, John Morrell & Co., Ottumwa, Iowa

In a study of the by-products operations at the Ottumwa plant of John Morrell & Co., it was found that considerable quantities of salable product were being lost in the plant's effluent. In the course of the past three years, three major changes have been made in operating procedures to reduce this loss. These innovations were installation of two automatically operated primary settling basins to permit recovery of grease and tallow separately from the plant effluent, installation of a solvent extraction plant to reduce the grease content of dry rendered cracklings, and finally the adoption of centrifugal equipment to dewater slush from wet rendering operations and to degrease tankwater destined for later concentration into condensed meat solubles in a multiple effect evaporator.

The most revolutionary of the changes made was the continuous centrifugal method for dewatering slush from rendering operations. Previously, dewatering was obtained by hydraulically pressing the sludge to get a cake having a moisture content of 55%, and a grease content of 10 to 12%. By the centrifugal method the solids discharged are of a fluffy characteristic more suitable for drying and analyze 50% moisture and usually less than 6% grease, both grease analyses being on a 6% moisture basis.

Through these new procedures, losses in grease in the plant effluent have been reduced from over 15 lbs. per thousand pounds live weight killed to approximately 4 pounds and nitrogen losses in the effluent have been reduced from 3 lbs. to 2 lbs. per thousand pounds live weight killed.

31. THE EFFECT OF ASCORBATE ON HEMOGLOBIN OXIDATION AND MEAT COLOR

BETTY M. WATTS, Syracuse University, Syracuse, N. Y.

The known reactions of ascorbate with heme pigments are reviewed and a method devised for following discoloration due to oxidation in hemoglobin or nitric oxide hemoglobin solutions.

At low concentrations and low temperatures, ascorbate protects hemoglobin solutions. At high concentrations and high temperatures it brings about oxidation and discoloration. Freezing, salt and low pH values accelerate the oxidation. Ascorbate may be useful in preserving the red color when applied in small concentrations to the surface of refrigerated (but not frozen) meats.

Ascorbate is generally useful in developing and maintaining "cured meat color" in hemoglobin solutions or meats containing nitrite. Uniform cured meat color in comminuted meats may be achieved by incorporation of a mixture of nitrite and ascorbate, followed by heating or freezing to accelerate color fixation. Nitrates and sugar have no effect on the reaction. Salt and low pH values accelerate color development. The possible mechanism is discussed.

32. BACTERIOLOGICAL ASPECTS OF PRE-PACKAGED MEATS

A. A. KRAFT and JOHN C. AYRES, Department of Bacteriology, Iowa State College, Ames, Iowa

A study was initiated to determine the effect of packaging foils and films on the keeping quality of fresh and cured meats. Preliminary results indicated that some wraps permitted greater bacterial growth than others. Of various packaging materials tested with fresh beef, a laminate of Pliofilm and aluminum foil was found to be most effective in retarding spoilage. Moisture-vapor proof cellophane yielded the most rapid proliferation of microorganisms on the surface of fresh beef. Storage end points were indicated by undesirable color, off odor, slime formation, and a given value for the numbers of microorganisms per square centimeter of meat surface.

The effect of these materials on color and weight loss of meat was considered. The bright red color of oxygenated beef was preserved best by moisture-vapor proof cellophane for a period of 72 hours, with darkening occurring after that time. Pliofilm ranked second in permitting color retention. Aluminum foil and Pliofilm-aluminum foil laminate provided a deoxygenated condition of the myoglobin, with subsequent brightening upon exposure to air after a storage period of as long as 12 days at 40°F. Weight losses were negligible with all films except waxed paper, moisture-vapor proof cellophane and semi-moisture-vapor proof cellophane.

At 45°F. frankfurters packaged in an atmosphere of CO_2 had an increase in storage life of 1.5 times that of control samples packaged in air. The keeping time was further prolonged by decreasing the temperature of storage.

33. PREVENTION OF RANCIDITY DEVELOPMENT IN FROZEN CREAMED TURKEY

HANS LINEWEAVER, JOYCE H. ANDERSON, and HELEN L. HANSON, Western Regional Research Laboratory, Albany, Calif.

A factor limiting the use of turkey in precooked frozen foods has been the tendency of products containing turkey meat and fat to develop a rancid flavor. In many cases the rancidity can be detected immediately after the product has been prepared, and it increases during frozen storage. During preparation and during storage of frozen creamed turkey, rancidity development is greatly retarded when small amounts of edible antioxidant are present during cooking of the turkey. Peroxide values and flavor scores have been used to show the advantage of cooking turkeys in the presence of an antioxidant. Comparisons made with samples of creamed turkey to which antioxidant was added after the birds were cooked indicate the value of cooking in the presence of antioxidant.

34. CANNING LITTLE TUNA

NORMAN D. JARVIS, Fishery Technological Laboratory, Branch of Commercial Fisheries, U. S. Fish and Wildlife Service, College Park, Md.

The "Little Tuna" *(Euthunnus alleteratus)* is found from Cape Cod southward all along the United States coast. It was formerly thought that the possible catch was not large enough for commercial utilization. Recent studies indicate a considerable catch off northern New Jersey, with the possibility of developing commercial catches in various other areas along the Atlantic and Gulf coasts. Small commercial packs have been made for several years. These show that a canned tuna of satisfactory quality may be prepared from the little tuna but that California methods of canning cannot be used unchanged. A study of all stages in canning little tuna was therefore made. It was found that excessive precook resulted in toughness of texture. When given the standard California process the color was darker than desirable for light meat tuna. A lighter color was obtained when the packs were processed at a lower temperature. A short process at higher temperature did not result in a light color. Acid dips and acid blanches were not effective. Chemical bleaches had a surface effect only. All vegetable oils were found satisfactory packing mediums except soy bean oil, which while usable was not as desirable as the others. Data were collected on yield, effect of freezing, and storage at various temperatures on raw material, thawing, precooking, type of fill, processing and cooling.

35. PRESERVATION OF VERY SMALL FISH IN THE PHILIPPINE ISLANDS

ARTHUR C. AVERY, Commissary Research Division of the U. S. Naval Supply Research and Development Facility, Naval Supply Depot, Bayonne, N. J.

Because of the shortage of fish in the Philippines, the Filipinos are forced to eat even the smallest of fish. To preserve these very small fish poses problems met in few other places in the world fish preservation industry. Methods used include: drying in sheets with and without salt; salting and prolonged hydrolyzation of the fish protein to produce pastes, semi-liquid condiments and clear liquid sauces; and combinations of salting, cooking and hydrolyzation which result in products which get a maximum of food value from fish that would go to waste in most parts of the world. Research by the U. S. Fish and Wildlife Service Philippine Rehabilitation Program resulted in new procedures that shortened preparation time of some of these products from periods of 6-18 months to 2-3 weeks by use of high incubation temperatures coupled with exclusion of oxygen.

36. FROZEN ATLANTIC OYSTER INVESTIGATIONS

SAMUEL R. POTTINGER, U. S. Fish and Wildlife Service, Boston, Mass.

Oysters can be and are frozen successfully. Only strictly fresh oysters of high quality should be frozen. Strict sanitary practices in the packing plant are essential. The package should be watertight to prevent leakage prior to freezing and should be moisture-vapor-proof if desiccation in storage is to be avoided. Freezing should occur at a reasonably rapid rate, and storage at 0°F. or lower is necessary to minimize quality changes.

37. FREEZING FISH AT SEA INVESTIGATIONS

JOSEPH F. PUNCOCHAR, U. S. Fish and Wildlife Service, Boston, Mass.

The trawler *Delaware* is currently being converted for freezing fish at sea. The vessel will be provided with an absorption type refrigeration system and fish will

be frozen in the round in a refrigerated brine medium at 0°F. After freezing, fish will be stored in a refrigerated storage space at 0°F. until the vessel reaches port. Frozen round fish will be thawed if fish fillets are to be prepared. The frozen round fish will be steaked if steaks are to be prepared. Slides of the lay-out of the vessel and the lay-out of the enlarged laboratory facilities at East Boston will be shown.

38. PROTEIN DENATURATION IN FROZEN AND STORED FISH

W. J. DYER, Atlantic Fisheries Experimental Station, Halifax, N. S.

Consumer acceptance has shown that the quality of frozen fish as marketed is often far from optimum.

The influence of various factors, such as time and temperature of storage and condition of raw material, as assessed by taste panels, is discussed.

Work on the denaturation of fish proteins has been undertaken with the object of attaining a better understanding of the mechanism concerned. Data on the denaturation of myosin by freezing and by salt, both in situ and in isolated form, have been obtained.

39. TRIMETHYLAMINE FORMATION IN FISH

DAVID W. ANDERSON, JR., and CARL R. FELLERS, Department of Food Technology, University of Massachusetts, Amherst, Mass.

Contrary to literature reports, many fresh water fishes were found to contain small amounts of trimethylamine. Tests involving the reduction of trimethylamine oxide by different bacteria indicated that the oxidation-reduction potential has a bearing on the reduction of the oxide to trimethylamine. Bacteria which were able to reduce the oxide created a reducing atmosphere in the medium. Aeration of the medium inhibited the reduction of the trimethylamine oxide. Attempts to obtain a cell-free preparation of triamineoxidase failed. An explanation of the mechanism of trimethylamine oxide in fish is offered. In the cod family it was found that the trimethylamine content of the muscle was not always a reliable test for freshness.

40. EVALUATION AND MATHEMATICAL PROPERTIES OF TASTE DISCRIMINATION SCREENING TESTS BASED ON TRIANGULAR ITEMS

S. HARRISON, N. H. ISHLER and E. LAUE, Central Laboratories, General Foods Corporation, Hoboken, N. J.

In designing and evaluating a screening test based on triangular items, the following points have been investigated:

1. Testing significance of observed differences in scores of tasters.
2. The level of item-difficulty which gives optimum discrimination between tasters.
3. Correction of scores for inflation due to sampling errors.
4. Correction of scores for item difficulty.
5. Determination of how many tasters to retain on the panel to give optimum discrimination.
6. Determination of optimum panel size in terms of dollar expenditure in running routine taste-tests.
7. Comparative efficiency of screening tests based upon items having chance expectancies other than 33⅓%.

41. BINOMIAL SYSTEMS AND ORGANOLEPTIC ANALYSIS

ERNEST E. LOCKHART, Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Mass.

Several simple test systems have been used to measure differences in the sensory characteristics of food products. When only two samples, A-B, are presented to a judge, the test has been called a paired difference, a quality judgment, a preference, or a consumer acceptance test. When three samples, AA-B, are employed, the test is called a triangle difference test.

The basic statistical principles underlying these tests are discussed in order to focus attention on their binomial similarity and to correlate these with more complex systems. These include symmetrical systems such as, AA-BB, AAA-BBB, etc., and asymmetrical systems such as, AAA-B, AAAA-B, AAA-BB, etc. The chance probability, usefulness and limitations associated with each of the systems are presented.

The properties of a pure difference test, a quality judgment test and the preference tests are reassessed and clarified. Both one-judge and more-than-one judge panels are discussed in connection with the various binomial systems.

42. SELECTION OF SENSORY TESTING PANELS

NORMAN F. GIRARDOT, DAVID R. PERYAM, and RUTH SHAPIRO, Quartermaster Food and Container Institute, Chicago, Ill.

General factors such as basic gustatory or olfactory acuity only partially determine a person's value as a member of a sensory testing panel. Factors which are specific to type of product investigated or kind of judgment required are perhaps more important, and effectiveness is lost if panel selection fails to take them into account. Demonstrated skill in tests involving these specific factors is the most efficient criterion. Attempted shortcuts in the panel selection process will tend to limit precision and will reduce confidence in definitive data.

Factors determining the desirability of using special selection procedures are discussed. A two-stage selection procedure is demonstrated. Starting with a large group of candidates, successive screenings are made through use of discrimination tests on differences between samples of the product type concerned. Tests on relatively large differences are first used to eliminate those who are obviously unqualified. These are followed by intensive testing involving various degrees and kinds of difference in order to rank the remaining candidates in order of skill. As many panel members as required may then be selected from among the high-ranking persons. The second stage of selection is employed when the panel will judge food quality. The candidates' performances are compared in a test situation that requires repeated judging of a series of samples representing a range of quality. The criterion of selection is the size of the ratio of the between-sample variance to the within-sample variance in the scale ratings.

43. TECHNIQUES WHICH HAVE BEEN EMPLOYED SUCCESSFULLY IN CONSUMER ACCEPTANCE TESTING

BEE ANGELL, Bee Angell and Associates, Chicago, Ill.

The problem involved in securing a measure of the consumer acceptance of a new product is discussed, along with the determination of the relative consumer acceptance of two formulae of a new product or two competitive products already being marketed.

The producer of a new product needs some indication of how well the proposed product will meet the needs and demands of the consumer before marketing costs

are incurred. Laboratory research alone cannot answer for the consumer. The producer of a product already on the market needs to know from the consumer's point of view how the product itself compares to those against which it must compete.

The general methodology, size and composition of sample and information developed are described and as illustrative examples are included a consumer acceptance test of two types of canned corn and one involving two cake mixes. A comparison is made of the relative effectiveness of two methods of testing: the side by side and the staggered test.

Some of the ways in which Marketing Management uses the result of consumer acceptance tests are also presented.

44. THE CONSUMER ANGLE—AS REVEALED BY NEWSPAPER CONSUMER ANALYSES

ARTHUR F. HALL, *The Milwaukee Journal*, Milwaukee, Wis.

1. What *is* a Consumer Analysis?
   a. When was the first Consumer Analysis made?
   b. For what purpose was it made?
2. Recent expansion of the Consumer Analysis idea.
   a. Fifteen markets now covered from coast to coast.
   b. How these surveys are correlated.
3. The Consolidated Consumer Analysis report for fifteen markets.
   a. When issued.
   b. What it contains.
4. How a Consumer Analysis is made.
   a. Preparation of questionnaire.
   b. Selection of homes to be covered.
   c. Coverage by areas.
   d. Adequacy of coverage.
   e. How questionnaires are returned and checked.
   f. Percentage of returns.
   g. Use of split sample; examples of sample stability.
   h. Correlation of store distribution figures.

CASE HISTORIES. Trends of certain food products as shown by *The Milwaukee Journal* Consumer Analysis: the rise and fall of various types of products and individual brands during the past thirty years. Some current trends.

45. RELATION OF TIME OF HARVEST AND AREA OF PRODUCTION TO YIELD, QUALITY, AND ACCEPTANCE OF DRIED FRUITS. I. PRUNES

JOHN H. KILBUCK, Division of Food Technology, University of California, Berkeley, Calif.

In California the area in which prunes are grown has a remarkable effect on abscission characteristics and consequently harvesting practices of prunes. In the cooler coastal areas the prunes tend to fall to the ground when reaching the firm ripe stage while in the warmer interior areas abscission does not take place for a month or more after the prunes reach the firm ripe stage.

In areas where abscission is slow to occur there is a tendency among some growers to harvest too late, which is shown by material losses in yield, quality and acceptance.

In the coastal areas decreases in these qualities occur, for the most part, after the prunes have fallen to the ground and before dehydration.

46. MICROBIOLOGICAL DETERIORATION OF DRIED FRUITS

E. M. MRAK, Food Technology Division, University of California

Fruits to be dried frequently undergo fermentation during the drying process and in storage after drying. The usual prune dehydration procedures, however, kill all yeasts and molds before the fruit emerges from the dehydrater. Subsequent contamination takes place during de-traying, boxing and storage. The temperatures used in the dehydration of figs are not sufficient to kill all yeasts, and populations of these organisms ordinarily increase during sun drying of all unsulfured fruits.

The pattern of the types of yeasts on dates, figs and prunes changes considerably from the time the fruit is harvested to the time it is dried and in storage. A wide variety of yeasts may be found on the fruit during pretreatment, and the early stages of drying. These ordinarily show a low tolerance to high concentrations of sugar, or adverse growing conditions. The genera commonly found during these periods are: *Saccharomyces, Hanseniaspora, Candida* and *Kloeckera.* As the fruit dries many of the less tolerant forms disappear and an abundance of sugar tolerant organisms such as *Zygosaccharomyces, Hansenula* and certain species of *Candida* are found.

47. THE MICROBIOLOGY OF DEHYDRATED VEGETABLES AND INDICES OF SANITATION

REESE H. VAUGHN, Division of Food Technology, University of California, Berkeley, Calif.

The results of detailed study indicate that common microbial indices of sanitation may not be applicable to all dehydrated vegetable products.

Microbial populations (bacteria, molds and yeasts) vary widely in finished dehydrated vegetables. With raw products of comparable quality the factors which influence the final populations the most are:

1. Chemical characteristics of the vegetable (presence or absence of antibiotic substances).
2. Method of pre-treatment (application of heat for blanching, peeling, etc.).
3. Efficiency of dehydration process.
4. Finishing temperature of dehydration.
5. Level of plant sanitation.

48. STORAGE OF DEHYDRATED VEGETABLES

R. R. LEGAULT, C. E. HENDEL, and WILLIAM F. TALBURT, Western Regional Research Laboratory, Albany, Calif.

Correlation has been made of the effects of moisture content, sulfite, package atmosphere, and storage temperature on deteriorative changes during storage of dehydrated white potato, carrot, cabbage, onion, and sweet potato. Substantial protection against browning is afforded by low moisture and also by sulfite. The degree of protection varies with the vegetable. Combination of 4 percent moisture reduction (from 9.2 to 5.3 percent) and sulfite (330 p.p.m.) increased the time for detectable browning of one lot of white potato by about 16-fold. In-package desiccation in containers of 4-inch height increased the time for a given degree of browning at 100°F. by about 2-fold for carrot, 4- to 6-fold for white potato, and 8- to 10-fold for cabbage and onion. Ascorbic acid loss and carbon dioxide evolution were also reduced by low moisture. Sulfite within Quartermaster specification limits increased the time for detectable browning in carrot by about 2-fold, and in white potato by about 4-fold. Sulfite afforded a slight protection for ascorbic acid. Oxygen of the package atmosphere (air vs. nitrogen) had little effect on

rates of browning, but greatly increased the destruction of ascorbic acid and carotene. Browning rates for the various vegetables were increased about 6- to 9-fold by temperature rise of 10°C.

49. HOW RESEARCH AND DEVELOPMENT ASSIST IN ARMY FEEDING

LT. COL. C. A. ROGERS, Army Food Service, OQMG

Although the Army had used emergency type rations during World War I, research and development application to foods for military use did not assume major importance until World War II. Varied conditions of combat operations throughout the War and the significance of shipping space provided the driving force behind military food research and development.

Dehydrated foods, emergency combat type rations and the packing and packaging problems received constant study. Results of these studies were translated into procurement actions. Lessons learned during World War II have been applied to a continuous program of research and development to the present time.

Analysis of the Army's military food problems is a continuing project under the joint sponsorship of the Food and Container Institute for the Armed Forces and the Associates, Food and Container Institute. Important research problems today include development of more acceptable dehydrated foods and acceptable and easily reconstituted dried whole milk, a spread for bread and an evaporated milk which will not separate during storage. Today's research and development problems are by no means limited to the foregoing.

50. COMMISSARY RESEARCH FOR THE U. S. NAVY

ALLEN LEVENSON, U. S. Naval Supply Research and Development Facility, Naval Supply Depot, Bayonne, N. J.

To deal with those problems of subsistence which are peculiar to the U. S. Navy, a research laboratory has been established at the Naval Supply Depot, Bayonne, New Jersey. Operating with a combination staff of skilled civilian technologists and experienced Supply Corps men and officers, the Commissary Research Division carries out research on special foods, specialized food preparation and food service equipment, Navy nutrition and other Naval subsistence projects in conjunction with cooperating industrial agencies.

51. ROLE OF FOOD INDUSTRY IN THE PRODUCTION OF NEW PRODUCTS FOR NAVAL SUBSISTENCE

LIEUTENANT COMMANDER J. A. CORRICK, JR., S. C., U. S. N., LENDAL H. KOTSCHEVAR and ARTHUR C. AVERY, U. S. Naval Supply Research and Development Facility, Naval Supply Depot, Bayonne, N. J.

New developments in naval warfare have increased demands on naval subsistence. More foods of better quality, taking less preparation time, containing less waste and occupying less space are being made available for the Navy's ships. This means that improvements have been made in most of the foods that were used in World War II. More and better pre-mixes are being developed. More concentrates are used. The dehydrates are being produced in better quality. The waste is being stripped from all foods, probably leading to prefabrication of most meats and the increased use of many precooked frozen foods of high quality. Canned food concerns are encouraged to have the maximum amount of better food in cans which occupy less space. All food processors and handlers are beginning to realize their responsibilities and to understand the importance of their contributions to an efficient and fighting Navy.

52. EVALUATION OF THE METHYL ESTER OF ALPHA NAPHTHALENE ACETIC ACID AS A SPROUT INHIBITOR FOR POTATOES UNDER ARMED FORCES CONDITIONS OF USE

JOSEPH R. WAGNER, FRANCES HEMPHILL, MORRIS SIMON, and BARBARA HEIBERG, Quartermaster Food and Container Institute, Chicago, Ill.

The effectiveness of the methyl ester of alpha naphthalene acetic acid for the control of sprouting and the extension of storage life of Quartermaster overseas' shipments of white potatoes has been investigated. Conditions encountered under prevailing crating, stowing, and handling practices which were followed in the shipping tests greatly reduced the effectiveness of the sprout inhibitor.

Supplementary laboratory studies have also been made on treated and untreated potatoes stored at 40°, 72°, and 90°F. Observations have been made on changes in histological structure, composition, rate of enzymic discoloration and utility and palatability characteristics.

53. EXTENDING SHELF LIFE OF COCOA TYPE COATINGS FOR USE IN ARMY RATIONS

JUSTIN J. ALIKONIS, Paul F. Beich Company, Bloomington, Ill.
and
KENNETH T. FARRELL, General Products Division, Quartermaster Food and Container Division, Chicago, Ill.

The extensive use of fats and oils in confectionery products for the armed forces of the United States has naturally caused more attention to be focused on the structure of these fats. The Quartermaster Corps has been interested from the standpoint of shelf life of coated candy bars used in various rations.

This paper on cocoa type coatings is the result of cooperative research of the General Products Division of the Quartermaster Food and Container Institute and the Research Laboratories of the Paul F. Beich Company.

The Armed Forces require cocoa type coatings which will stand up for long periods of time at temperatures up to 120°F. for use in desert and tropic areas. These coatings are not only to withstand these high temperatures, but must be palatable, nutritive, and not stick to the wrappers. Previous use in these cocoa type coatings of fats with softening or melting points in the 120°F. range, which will not melt at body temperature, gave an undesirable shortening taste. The use of low melting point fats which bleed out in hot weather resulted in a gray, unpalatable, sticky coating.

Since the vegetable fats from high lauric sources have the best properties from the standpoint of resisting rancidity, they were tested with various food emulsifiers. To these vegetable fats with different predetermined melting points were incorporated various percentages and combinations of emulsifiers and these were observed at high temperatures and high relative humidities.

It was found that a certain combination of emulsifiers produced an unusual and unexpected result. The vegetable fats with the emulsifiers added had a tendency to up-grade the melting points of these vegetable fats, i.e., these coatings would stand higher temperatures than the predetermined melting points of the vegetable fats used. On the other hand, the coating without the emulsifiers broke down at the temperature of the predetermined melting points of the vegetable fats used. The addition of non-fat milk solids to the cocoa type coatings gave confections which not only withstood higher temperatures, but at the same time eliminated the waxy, shortening taste. Although the melting points of the fats used in the cocoa type

coating are higher than body temperatures, the emulsifiers tend to incorporate this fat into a creamy mass which, when eaten with the centers of the various bars, produce a very palatable and nutritive type confection. Another advantage is that these emulsifiers keep the coating from sticking to the wrappers and prevent the greasy feeling that is so often associated with the use of hydrogenated vegetable fats.

Thus the shelf life of Quartermaster Cocoa type coatings has been improved, and these improvements have been incorporated in the new revision of Quartermaster specifications on confectionery products. Two cocoa type coatings are available in the Quartermaster Corps specifications, one with 7.5 percent cocoa, known as light coating, and the other with 17.5 percent cocoa, known as dark cocoa coating.

54. FACTORS AFFECTING THE STABILITY OF COLOR OF CANNED RIPE OLIVES

W. V. CRUESS, Food Technology Division, University of California

The color of canned ripe olives is developed by oxidation at slightly alkaline reaction during pickling. The pickled fruit is preserved by processing in cans or jars at 240°F. The pH value during oxidation to develop color affects its stability, as does also the NaOH concentration used in final lye application to destroy bitterness. The NaOH is leached from the fruit with water to reduce the pH to about 7.5 or less. If pH is too high, color will be lost during retorting; if washing is too prolonged, bacterial activity may cause bleaching of the color. In plain tin cans the color bleaches fairly rapidly finally becoming brown or yellow, but is well retained in enamel lined cans and in glass. The application of dilute $CaCl_2$, $MgCl_2$, or diluted sea water or diluted salt factory bittern stabilizes the color very remarkably. Color is better retained during pickling if hard water rather than soft is used.

55. THE REACTION BETWEEN PROTEINS AND REDUCING SUGARS IN THE "DRY" STATE

C. H. LEA and R. S. HANNAN, University of Cambridge, Low Temperature Research Station, Cambridge, England

The free amino groups (both ε- and α-) of proteins react stoichiometrically with glucose during the early stages of interaction in freeze-dried mixtures at approximately neutral pH, the maximum rate of change occurring in the presence of water and sugar approximately sufficient to cover the surface of the protein. At this stage marked lysine deficiency results, although solubility has not been affected and color only slightly.

Subsequently, other "essential" amino acids become involved, the protein darkens and becomes less soluble, and dialysable decomposition products accumulate.

Decomposition of carbohydrate attached to protein amino groups has been shown to account for much of the darkening in a casein-glucose system at 37°C. In an acetylated casein-glucose mixture interaction and browning are both much slower, but are still appreciable at 37°C. and very rapid at 60°C.

Polylysine and α-N-acetyl-L-lysine react with glucose to reproduce most of the characteristic features of the protein-sugar reaction. At 20% relative humidity extensive combination takes place without appreciable browning or pH change, but at higher humidities the typical symptoms of the Maillard reaction occur. As with the protein-sugar reaction, the secondary effects have a higher optimum humidity (60%) than the amino-sugar reaction (40%). Paper chromatography of the acetyl-lysine system distinguishes (a) a one-to-one combination product, probably the N-glycoside, (b) a rearranged form of (a), (c) at least four fluorescent compounds and (d) brown humin-like material. (a) and (b) are colorless but their decomposition on storage accounts qualitatively for most of the effects observed in the intact system.

56. SPOILAGE BACTERIA IN TOMATO PRODUCTS

L. S. WHITE, Department of Biochemistry, Ontario Research Foundation, Toronto, Ontario, Canada

Packers of tomato products experienced moderate to substantial losses by low heat resistant organisms. Flat sours in low spore loads caused spoilage in high pH juice when low temperature processing was employed.

57. HYDROLYTIC ACTION OF *PSEUDOMONAS FLUORESCENS* ON FATS

MORRIS L. GOLDMAN and MORTON M. RAYMAN, Stability Division, Quartermaster Food and Container Institute for the Armed Forces, Chicago, Ill.

The rate and degree of bacterial hydrolysis of finely emulsified animal and vegetable fats have been followed by titration of the liberated fatty acids and also by gravimetric determination of the residual unattacked oil. Oil in concentrations up to 20 grams per 100 ml. of the emulsion medium has undergone a 90-95% cleavage by *Pseudomonas fluorescens* in 6 weeks or less. Approximately the same degree of bacterial hydrolysis was obtained with butteroil, tallow, lard, coconut oil, soybean oil, and cottonseed oil.

A suitable emulsion medium has been developed for the study of bacterial metabolism of fats. This medium has the following advantages: 1. uniformly fine emulsion (globule size less than 1 micron diameter) providing maximum oil surface for bacterial attack, 2. stability to autoclaving and 3. suitable nutrients favoring lipolysis. For detection of lipolytic bacteria in food products this medium can be modified by addition of agar and Nile blue indicator to provide a superior lipolytic plating medium.

The oil-in-water emulsions were prepared by pressure homogenization at 2500 psi using a phospholipid dispersing agent. Application can be made of such emulsions for assaying the potency of animal and vegetable lipase preparations.

58. SO YOU HAVE TO WRITE TECHNICAL REPORTS

MARTIN S. PETERSON, Quartermaster Food and Container Institute, Chicago, Ill.

Preparing a technical report, whether a routine progress report, the so-called interim report, or a termination report, is a task not always enjoyed and in some instances despised. If the data to be reported are not very promising the task is particularly hard—particularly so in the initial phases of an investigation.

Technical people sometimes behave in curious ways in the face of writing reports. In preparing *progress reports*, for example, they may take one or another of the following approaches: (1) covering up lack of data or incoherent data with scientific nomenclature, (2) leading up to a point, perhaps a good point, and then negating it, (3) describing the reasons why no progress has been made, (4) preparing the data without regard to logical sequence. These four approaches might, in a spirit of levity, be dubbed, respectively, (1) the "eenie-meenie-minie-mo," (2) "down the rabbit hole," (3) "I'm forever sharpening pencils," (4) "the drunken sailor," the last mentioned indicating the zig-zag trail some report writers take to their destination.

A good progress report requires a key opening statement, identification of the major aspects of the data, emphasis on the significant trends or findings, a final statement providing the full implications of the data accumulated.

Interim reports, which are used to crystallize, as it were, major findings prior to the termination of a project, are similar in many respects to journal articles in organization. They fail when they are mere "flashes of insight," overelaborate treat-

ment of routine findings, or too vague in concept. A brief background statement reviewing the objective and plan of attack, procedures, discussions of results, and conclusions reached is the conventional formula. A good interim report reflects a systematic plan of work, analytic thought in arranging the results, the meaning behind the data.

Termination reports pull the whole investigation together and leave the reader with the essential accomplishment.

If all report writers were perfect transcribers of their findings they would eliminate the need for technical editors. Such an occurrence would be a sorry fate for technical editors because your true technical editor enjoys working with the most unpredictable catalysts in the world—words.

59. PASTEURIZED FRESH WHOLE PICKLES. I. PASTEURIZATION STUDIES

W. B. ESSELEN, JR., E. E. ANDERSON, L. F. RUDER, JR., and I. J. PFLUG, Department of Food Technology, University of Massachusetts, Amherst, Mass.

During the 1949 and 1950 seasons heat penetration, spoilage, bacteriological and other data were obtained on 55 experimental packs of pasteurized whole fresh pickles put up in the laboratory and in commercial pickle plants. The data so obtained provide a basis for evaluating variations in heating rates, processing values, brine volume and acidity, firmness, and process requirements to prevent spoilage in this product. A majority of the experimental packs were pasteurized at 180°F. The sterilizing value of pasteurization times from 5 to 40 minutes were evaluated on a basis of F_{180} with a z value of 18. A minimum sterilizing value equivalent to at least 36 minutes at 160°F. was required to prevent spoilage under the conditions employed. Equivalent pasteurization times at other temperatures have been derived from these data. Inherent variations in the tightness of pack as due to variations in raw material and method of packing with their corresponding effects on rate of heat penetration appear to have a more important effect on the pasteurization time required than do variations in the acidity (14 to 30 grain acetic acid brine at time of filling) within the limits used. Pasteurization up to 40 minutes at 180°F. or its equivalent at other temperatures had no adverse effect on the flavor and texture of the product.

60. PASTEURIZED FRESH WHOLE PICKLES. II. THERMAL RESISTANCE OF MICROORGANISMS AND PEROXIDASE

E. E. ANDERSON, L. F. RUDER, W. B. ESSELEN, JR., E. A. NEBESKY, and M. LABBEE, Department of Food Technology, University of Massachusetts, Amherst, Mass.

The bacteria count of pasteurized fresh whole pickles decreased rapidly during tht first 15 minutes of pasteurization at 180°F. After 20 minutes the count attained a low level which showed little or no decrease up to 40 minutes at 180°F. Of 78 cultures of microorganisms isolated from spoiled jars of pickles, 30 survived heating for 10 minutes at 165°F. in 3.2 grain acetic acid pickle brine. When inoculated into sound jars of pickles and tubes of pickle brine, four of these organisms grew and produced typical spoilage characteristics. These cultures consisted of two each of Lactobacilli and yeasts. The Lactobacilli caused spoilage characterized by cloudiness followed by sediment formation and the yeasts produced cloudiness and gas followed by sediment formation. These four organisms were capable of growing in pickle brines containing 10 to 12 grains acetic acid and in relatively high salt concentrations. The heat resistance of these organisms was sufficiently great to implicate them as causative spoilage agents in the spoilage of pasteurized fresh whole cucumber pickles under conditions where minimum rates of heat penetration are encountered as pointed out in paper I of this investigation.

The tendency of these pickles, if not pasteurized sufficiently, to develop an off or "stale" flavor during storage appears to be related to the destruction of peroxidase and related enzymes. The off flavor is similar to that which is caused by adding a peroxidase preparation to pickles. In some cases a slightly longer process was required to prevent the development of this off flavor than to prevent microbial spoilage. The additional process required to control enzymatic action did not impair the texture of pickles and resulted in a better retention of flavor during storage.

61. THE DEVELOPMENT OF A NEW PROCESS FOR CURING COFFEE

WILLIAM R. JOHNSTON and H. ELLIOTT FOOTE, The Fleischmann Laboratories, Standard Brands Incorporated, New York, N. Y.

A practical process for consistently preparing top quality green coffee has been developed. It has been shown that in a given producing area the highest quality green coffee is obtained by rapid curing under conditions which cause no substantial change in the coffee bean other than dehydration to a moisture content of 10 to 12%. Fundamentally, the new curing process depends on the substitution of controlled enzyme action for spontaneous fermentation and the substitution of rapid drying for slow and inefficient drying.

The new process in its preferred form comprises:

1) Mechanical removal of the skin and some of the pulp of the coffee cherries to yield "pulped beans."
2) Pectic enzyme digestion at ambient temperature of the residual mucilaginous layer coating the "pulped beans."
3) Washing of the digested "pulped beans."
4) Mechanical drying in 4 to 6 hours of the digested, washed pulped beans (beans in clean parchment).
5) Hulling and grading by accepted methods.

Pectic enzyme digestion of the coffee cherry mucilage is the most important step in the new curing process. Providing this step is employed, many variations of the preferred process may be made with good results. The economics of coffee curing in a given area will determine the feasibility of any given variation of pectic enzyme curing.

Through the use of the new coffee curing process more than one billion pounds of relatively low grade coffee produced every year in Brazil could be replaced by superior coffee fully equal in quality to many Latin American coffees now eagerly sought by the coffee buyers of the United States. Recent reports from many of the coffee countries indicate great interest in the new process, even in those countries now producing good washed coffee, because pectic enzyme curing offers the means for the first time of insuring the production of top quality coffee instead of the usual production of coffee of variable and unpredictable quality.

62. RELATION OF KETCHUP COLOR TO TOMATO COLOR AS DETERMINED BY THE HUNTER INSTRUMENT

ROBERT E. BUCK and RUTH A. SPARKS, H. J. Heinz Company, Pittsburgh, Pa.

The Hunter Color-Difference Meter has been used to study tomato and finished ketchup color in a full production operation for an Ohio ketchup factory. Color measurement was made on a heated extracted sample of whole tomatoes. Color wat

relatively good and relatively constant throughout the season. Results show that small changes in ketchup color can be correlated with changes in raw tomato color, and the differences can be measured objectively and expressed numerically. Some data were collected on color grading of raw tomatoes, but not sufficient to permit drawing definite conclusions regarding the relation between present P. M. A. grade color and finished ketchup color. However, the above results indicate the possibility of this means for setting up grade color standards which will have a definite relationship to the finished ketchup. The processed product color should be the determining factor in setting grade color standards for the raw product. Present grade color standards for juice tomatoes are based largely on outside surface color which may not reflect the overall color of the tomato. They also permit large variations within the grades.

The proposal is made from the above considerations that standards most desirable for juice grade tomatoes should reflect the overall color of the product that can be made therefrom and also be capable of revealing small differences accurately.

Some miscellaneous tomato color studies are also reported on varietal and maturity differences.

63. THE USE OF MODIFIERS IN CHOCOLATE

NELSON R. EASTON and LESTER R. BARTRON,
Lehigh University, Bethlehem, Pa.

The effects of many additives in modifying the stability of chocolate have been investigated. Several of these modifiers, when properly used, improve the resistance of chocolate to fat bloom. Mixtures of sorbitan monostearate and polyoxyethylene (20) sorbitan monostearate (Span 60 and Tween 60, e.g., G-2034) have been found most effective for this purpose.

Extensive studies of time-temperature relationships for the proper tempering of chocolate have been made and the results emphasize the importance of a correct tempering procedure in the use of these modifiers. As a generalization, if the addition of a modifier increases the viscosity of the chocolate mix, a shorter tempering period is desirable: if the modifier thins the chocolate, the tempering period should be extended.

A convenient method for predicting the degree of temper in the finished product based upon measurements on molten chocolate will be described.

64. THE EFFECTIVE CONTROL OF MOLD GROWTH ON WALLS AND CEILINGS OF FOOD PROCESSING PLANTS

LLOYD B. HERMAN and CLYDE L. REED, Wilson & Co., Inc., Chicago, Ill.

The use of water soluble copper salts for the control of parasitic plant fungi has been a recognized agricultural practice for many years. Unfortunately, copper in an ionizable and soluble form shows many undesirable characteristics, especially when used in food processing plants.

Recently, a much more useful compound in which the copper content has been completely chelated, or rendered non-ionizable, and thus non-toxic for animal life, while still retaining its fungicidal activity, has been found in a specially treated copper-8-quinolinolate. This material is soluble in many common non-polar types of solvents. Water emulsions are readily made and have shown an *in vitro* inhibition of growth of 75 individual strains and species of yeasts and molds normally found in food processing plants.

The specific areas where this material has been shown to be effective include the walls and ceiling of receiving, processing, curing, storage and shipping rooms, especially where high humidities and surface condensation of moisture encourages the growth and production of both mold mycelium and spores. Such surfaces have been protected through the use of (1) surface sealing compounds, ((2) paints and (3) water resistant surface coatings containing the specially treated copper-8-quinolinolate.

65. SEQUESTERING AND VITAMIN C DESTRUCTION BY COPPER

ROY E. MORSE, Food Technology Laboratories,
Monsanto Chemical Co., Anniston, Ala.

Effects of destruction of vitamin C by copper were observed in pure solution. Protective action of metaphosphoric acid and citrate-phosphate buffers are shown to be due to sequestration. A non-sequestering buffer consisting of the system dichloracetic acid—sodium dichloroacetate is suggested for studies on effect of copper on vitamin C.

Work with tomato juice shows certain molecularly dehydrated phophates are capable of significantly lowering vitamin C destruction in the presence of copper during juice preparation. Other effects are discussed.

66. INCIDENCE AND SIGNIFICANCE OF MICRO-ORGANISMS IN CITRUS JUICES

L. W. FAVILLE and E. C. HILL, Citrus Experiment Station,
University of Florida and Florida Citrus Commission

Microbiological examinations of 157 batches of citrus juice, including 112 orange, 30 grapefruit and 15 tangerine, indicate that juices extracted under the most ideal commercial conditions may contain a wide range of microorganisms. Evidence is presented to show that the citric acid content of the fruit used is one of the most important factors involved. The significance of the presence of microorganisms in citrus juices is discussed.

67. THE UTILIZATION OF CITRUS FRUIT PROCESSING WASTES. MICROBIOLOGICAL PRODUCTION OF RIBOFLAVIN AND CITRIC ACID FROM CITRUS MOLASSES

ELMER L. GADEN, JR., DEMETRE N. PETSIAVAS, and JOSEPH WINCKER,
Columbia University, New York, N. Y.

The use of citrus molasses, a by-product of juice concentrate preparation, for microbiological production of riboflavin and citric acid has been studied. Experimental results indicate that the molasses may be sufficiently enriched with riboflavin for feed supplement use. Riboflavin is produced by *Eremothecium Ashbyii (NRRL 1363)* under a variety of experimental conditions. Citric acid could not be produced from raw citrus molasses by submerged growth of *Aspergillus niger (NRRL 599)* under any of the conditions used. Refined molasses yielded acid when suitably supplemented.

68. GELATION AND CLARIFICATION IN CONCENTRATED CITRUS JUICES. I. INTRODUCTION AND PRESENT STATUS

F. W. WENZEL, A. H. ROUSE, and E. L. MOORE, Citrus Experiment Station, University of Florida and Florida Citrus Commission, Lake Alfred, Fla.

An introduction to the problems of gelation and clarification in concentrated citrus juices, the occurrence of which lowers the quality of these products. Frozen citrus concentrate must be properly processed, stored and distributed to the consumer otherwise gelation and clarification may occur.

Gelation and clarification in citrus concentrate are the result of enzymatic changes and many factors determine the rate at which these changes take place. Basic factors of importance are the pectin concentration, the pH, the bivalent ion concentration and enzyme activity in the concentrate.

Possible methods for the prevention of gelation and clarification in citrus concentrate are discussed. The possible use of variations in processing procedures, heat inactivation of enzymes, chelating agents and enzymatic inhibitors as preventative measures are presented.

69. GELATION AND CLARIFICATION IN CONCENTRATED FRUIT JUICES. II. EFFECT OF QUANTITY AND TYPE OF PULP IN THE CONCENTRATE

R. W. OLSEN, R. L. HUGGART, DOROTHY M. ASBELL, and C. D. ATKINS, Citrus Experiment Station, University of Florida and Florida Citrus Commission, Lake Alfred, Fla.

The quantity of pulp in concentrated citrus juices is shown to be a factor affecting gelation and clarification in these products. The type of pulp is also a factor on which gelation and clarification depends since the pulp may contain, in addition to juice cells, other portions of the fruit such as albedo, rag or seeds that introduce pectic substances and enzymes into the concentrate.

Experimental packs of Pineapple orange concentrate and Duncan grapefruit concentrate were processed in the pilot plant at the Florida Citrus Experiment Station. These concentrated citrus juices contained different types of pulp in varying amounts. Data are presented showing degree of gelation, degree of clarification, pectase activity and pulp content in these packs of concentrated juices.

A practical procedure for determining and grading the degree of gelation in citrus concentrate is also presented.

70. EXPERIMENTAL TREATMENT OF CITRUS WASTE WATER

ROBERT R. MCNARY, RICHARD W. WOLFORD, and VINCENT D. PATTON, Florida Citrus Commission, Citrus Experiment Station, Lake Alfred, Fla.

Investigations over the past five years on various methods of treating waste water from citrus processing plants are discussed. Methane fermentation appeared to be suitable as a treatment but factors arose that interfered with this type of fermentation. It was found that the essential oil from citrus fruit is toxic to these anaerobic bacteria. The essential oil can be eliminated from citrus liquors by allowing fermentation with naturally occurring yeasts to take place at the same time the liquor is aerated. After this treatment excellent results can be obtained by methane fermentation.

71. FRUIT FLAVORS

J. H. MCGLUMPHY, Van Ameringen-Haebler, Inc., Elizabeth, N. J.

A combination of improved methods for the concentration of fruit flavors is described. Proper application of this procedure results in flavor concentrates containing practically all of the flavor present in the original fruit.

The known aromatic constituents of the more important of fruits are reviewed.

The trend toward improved synthetic fruit flavors, based on rapidly expanding knowledge of the responsible flavor components in fruits is discussed.

A report of analytical findings is given, confirming and extending the known list of volatile flavoring materials naturally occurring in strawberries and raspberries.

72. PREPARATION OF TERPENELESS OILS

MORRIS B. JACOBS, Polytechnic Institute, Brooklyn, N. Y.

Terpeneless and sesquiterpeneless oils are made by several processes which are generally variations of either distillation or solvent extraction methods. Terpeneless oils can be prepared by a differential solvent extraction method. Such terpeneless oils are superior in flavor and bouquet to those prepared by fractional distillation because they retain more of the original ester content. A differential solvent method for the preparation of terpeneless oils is detailed.

73. THE EFFECT ON THE FLAVOR OF STRAWBERRY PRESERVES CAUSED BY PARTIAL REPLACEMENT OF SUCROSE WITH OTHER SWEETENERS

ROBERT L. SWAINE, Arthur D. Little, Inc., Cambridge, Mass.

A flavor analysis was conducted on strawberry preserves, prepared on a laboratory scale, with partial replacement of sucrose by corn syrup solids and dextrose hydrate. Findings show that differentiation in flavor between all-sucrose samples and the replacement samples was possible. Triangular taste tests and flavor profile analyses were used to detect and measure the differences. The flavor characteristics on which these differences were based are given.

74. AN EVAPORATOR FOR THE CONCENTRATION OF CITRUS AND OTHER FRUIT JUICES

C. D. ATKINS, Florida Citrus Commission, Citrus Experiment Station, Lake Alfred, Fla.

The construction, operation, and use of an evaporator designed principally for the concentration of citrus juices, but also applicable to the processing of other fruit juices is described. This evaporator resulted from the cooperative research efforts of the University of Florida Citrus Experiment Station and the Florida Citrus Commission. It was built and installed as a pilot plant unit at the Citrus Experiment Station, Lake Alfred, Florida. For reasons of operating efficiency as well as product quality this unit continues to be used for research projects carried on by these Florida State Agencies for the benefit of the citrus processing industry.

The two-stage thermocompression unit operates at high vacuum and low temperature with juice circulating rapidly over warm evaporating surfaces.

Based on this design large commercial evaporators capable of removing 30,000 lb./hr. of water vapor from citrus juices, have been designed and constructed. The techniques of these units and their operation are discussed.

75. ECONOMIC, FUNCTIONAL AND BACTERIOLOGICAL ASPECTS OF A CARRIER-HOWARD CONCENTRATOR AS APPLIED TO FOOD PRODUCTS

J. B. MERRILL, Carrier Corporation, Syracuse, N. Y.

The economic aspect of the Carrier-Howard concentrator embodies many features. Without the intention of discussing these features at length, this paper is presented to point them out in an engineering manner.

This concentrator, by virtue of its coordinated design, and the use of Freon 11 as a refrigerant, is all of low pressure construction, providing for low first cost, as well as low insurance cost.

This unit is built in multiple effects, and embodies the warm and cold sources to be supplied by a centrifugal compressor which is economy through maintenance and operation costs. Water consumption and steam consumption (steam in this case for use in evacuation of non-condensables) are each held to a minimum in this type of design.

The functional aspect of the Carrier-Howard concentrator has taken into account the following points: Temperature of evaporation conforming with flavor retention of the product handled, coupled with the proper selection of heating medium temperatures that will not allow film temperatures to be excessive; and this, coupled with an engineered selection of tube diameters assures product temperatures to be held at a minimum by transferring latent heat of evaporation only, and not any sensible heat.

The bacteriological aspect has always been considered one of prime importance to a high quality product. Accordingly, these concentrators are designed so that the surfaces in contact with the product being handled are always washed with new product, not allowing any product to be residual in the plant, and subsequently picked up by the new product.

Retention time, material in process, and clean-up times are all held to the absolute minimum by virtue of design and operation.

76. LOW TEMPERATURE EVAPORATION OF FOODS

JOSEPH A. CROSS, Mojonnier Brothers Company

The equipment to be described is a Lo-Temp Evaporator which operates on the principle of secondary recompression or indirect thermo-compression, and in which ammonia gas is used instead of steam as the heating medium.

A complete description with illustrations will be made on the principle and operation of the evaporator together with an analysis of operating costs, and economic advantages of low temperature evaporation will also be fully covered.

Typical installations in food plants in various parts of the country will be illustrated and explained, and the range of food products which are being processed at low temperature will be covered, with the recommended temperatures at which evaporation should take place for maximum flavor quality in various food products. Other food products on which experimental work has been done, or which it is believed will lend themselves favorably to low temperature evaporation will also be covered, with an explanation of the possible savings and other advantages that would accrue when concentrating at low temperatures.

77. LOW TEMPERATURE EVAPORATION OF FOOD PRODUCTS

LEWIS W. HULL and EARL W. FLOSDORF, F. J. Stokes Machine Co.
Philadelphia, Pa.

Modern vacuum techniques permit economical removal of water from food products at low temperatures. The nature of the food product to be dried determines the general classification of vacuum drying equipment and method best suited. Quantities to be dried also affect selection.

Broadly, the products to which low temperature vacuum evaporation may be applied may be classified as those having a solid form and those which are liquids or semi-solids. Either of these may be dried at temperatures above freezing or below. The former classification includes vegetables and meats. These may be handled in (A) a rotary vacuum dryer, (B) a rotating vacuum dryer or (C) a shelf vacuum dryer. The first two mentioned may be used for temperatures above freezing and the last for either above or below.

Semi-solid foods include such foods as fruit juices, milk, extracts and raw eggs. At temperatures above freezing, pan vacuum dryers may be used. Belt vacuum dryers, drum vacuum dryers and shelf vacuum dryers may be used at temperatures either above or below freezing.

The techniques and products applicable to, various vacuum producing means, and finally the limitations of and cost data on each of the above-mentioned methods are presented.

78. LOW TEMPERATURE EVAPORATORS

ALBERT W. ECKSTROM, Buflovak Equipment Division, Buffalo, N. Y.

This paper describes the engineering design features and performance of the Buflovak low temperature evaporators: Why the downflow type is adaptable to low temperature evaporation and its advantage over natural and forced circulation types; methods of construction for complete sanitation and ease of cleaning; advantage of multiple effect; operating difficulties and methods of overcoming them; various type products handled in this type of evaporator; vapor recompression type versus heat pump system and their advantages from an operation and economical viewpoint; when should low temperature be used and its advantages for producing a high quality product; design features which help to produce a high quality product; data and information acquired from this type evaporator, applicable to products processed under either higher temperatures or other exacting conditions; discussion of control instruments and their advantage for maintaining uniform concentration and ease of operation.

79. COMPARISON OF LOW-TEMPERATURE EVAPORATORS

HUGH W. SCHWARZ, Minute Maid Corporation, Plymouth, Fla.

The various types of low-temperature evaporators are outlined briefly, and the process and product differences are compared. The problem of choosing an evaporator is discussed from the point of view of the purchaser. Factors such as utility requirements, first cost versus operating cost, range of operation, hold-up, insurance coverage, and waste disposal are covered. The questions of ease of operation and special requirements involved in start-up and shut-down are brought out. The type of instrumentation is discussed and several special cases are considered. A discussion of requirements for sanitary design, problems such as hesperidin build-up, and method of cleaning is given. A particular case involving the choice of an evaporator for an existing plant is studied.

80. CONTROL OF SANITATION IN FOOD AND DRUG PLANTS

C. A. HERRMANN, New York District, Food and Drug Administration,
New York, N. Y.

To discharge his full responsibility, the food technologist must recognize and, at least in some phases, deal with the sanitation problems in his plant. He cannot ignore them on the pretext that they are the exclusive concern of the sanitary engineer or the hired exterminator. As he deals with improvements in products, ways

of achieving uniformity of output, innovations in packaging, reduction in costs of

of achieving uniformity of output, innovations in packaging, reduction in costs of production, or any of the multitudinous facets of his profession, the food technologist must come to grips with the various basic applications of sanitary control. This compulsion derives its force from the adulteration sections 402(a)(3) and (4) of the Federal Food, Drug, and Cosmetic Act.

In the Food and Drugs Act of 1906, the adulteration section relating to sanitation was restricted to the finding of the product itself in whole or in part filthy, putrid, or decomposed. In the Food, Drug, and Cosmetic Act of 1938 these concepts not only are broadened to include the generalized category: "or if it is otherwise unfit for food," but they have added to them a new type of vice, namely, "if it has been prepared, packed, or held under insanitary conditions whereby it may have become contaminated with filth or whereby it may have been rendered injurious to health."

These new definitions make the primary problem of sanitation in a food plant one of prevention—that is, building and blocking out rodents, vermin, and insects, controlling the raw materials coming into the plant, supervising the human behavior during processing and packaging, designing and maintaining conveyors, machinery, and utensils in order that they themselves will not become a source of contamination, and packaging, storing, and distributing the finished articles of food so that they will reach the ultimate consumer without deterioration or contamination.

In the measure that these requirements touch the food technologist, to that extent must he meet their challenge.

81. DEVELOPMENT OF SELF-INSPECTION FOR SANITATION IN FOOD PLANTS OF NEW YORK CITY

JEROME TRICHTER, New York City Health Department, New York, N. Y.

The responsibility of food plant operators in connection with violations of the sanitary laws is well defined and generally familiar. Prosecution in the courts, bad publicity, loss of prestige, and even shutting down the plant may be the consequence of failure to comply. Today, in making self-inspection mandatory, health authorities have given industry an added responsibility. Food plant operators are now required to make regular periodic in-plant surveys to find and record sanitary code violations. This self-inspection must be made by a qualified person; either an outside sanitarian or one employed by the company in an administrative capacity. In the City of New York where this system is now in use with much success, the Health Department trains company personnel without charge. This instruction includes Sanitary Code principles, the technique of inspection, use of appropriate recording forms and the treatment of new problems as they occur. The company inspector in this way maintains active liaison with the inspection service of the official agency. Mutual understanding of common problems becomes inevitable.

Self-inspection is not a substitution for official inspection. Carried out earnestly and effectively it reduces the frequency of official inspection but periodic checking by the official agency still is necessary. The checking is of a different kind, however, with many marked advantages to industry and the Health Department. The added responsibility of self-inspection is productive and profitable in the major aspects of plant operation. For this reason many food technologists in various parts of the country are utilizing it even though the local regulatory agency may not require it.

82. STAPHYLOCOCCUS FOOD POISONING

M. S. BERGDOLL, M. J. SURGALLA, and G. M. DACK, Food Research Institute, The University of Chicago, Chicago, Ill.

The main purpose of this investigation was to determine the chemical nature of the *Staphylococcus* enterotoxin in hopes that this would lead to the development of a satisfactory assay method. The first part of the investigation was concerned with the development of methods for producing enterotoxin in sufficient quantities for chemical studies. Satisfactory methods have been developed and used for this purpose. Studies on the use of frogs for assay of enterotoxin are still in progress. Immunological technics for indication of the number of antigenic components present in toxin samples are being developed to aid in the purification studies.

The methods most commonly used for the purification of toxins, enzymes, and other proteins have proved useful in the purification of enterotoxin. Positive enterotoxin reactions in monkeys were obtained with as little as 0.62 mg. of partially purified material that contained 0.07 mg. nitrogen.

The following observations warrant the tentative conclusion that enterotoxin is a protein: (1) It is precipitated by ammonium sulfate, (2) it is precipitated by adjustment of the hydrogen ion concentration, (3) it is apparently inactivated by ethanol and heat under certain conditions, and (4) it is apparently digested by trypsin.

83. DEVELOPMENT OF GUIDING PRINCIPLES FOR THE USE OF CHEMICAL ADDITIVES IN FOODS

H. E. LONGENECKER, University of Pittsburgh, Pittsburgh, Pa.

In recent years, science has placed in the hands of the farmer and the food handler, processor, and distributor, many valuable chemical tools to assist in the unending effort to benefit the health of people through an improvement of their nutritional status.

Pesticidal chemicals have aided in the production and protection of an adequate total supply of food; many other chemicals have aided in preventing food spoilage or in importing some special quality attractive to the consumer.

With the increased use of chemical additives, additional stress has been placed on the need for early resolution of a long standing problem of determining and gaining agreement to a body of guiding principles involved in evaluating the desirability of use of individual chemical additives in foods.

The efforts of the National Research Council's Food Protection Committee to reach a set of guiding principles will be reviewed.

84. PESTICIDES ESSENTIAL TO FOOD PRODUCTION

L. S. HITCHNER, National Agricultural Chemicals Association, Washington, D. C.

The paper will point out briefly the essentiality of control pesticides in the production of food. The implications of the Residue Tolerance Hearings will be discussed; the proceedings of the Delaney Committee from the viewpoint of NAC will be reviewed; and the mass of existing legislation and control also will be discussed from the viewpoint of the producer and consumer of pesticides. The importance of adequate protection to the public health, with which our industry heartily agrees, also will be a subject of comment.

85. REFLECTIONS ON GAUGING THE TOXICITY OF CHEMICALS IN FOODS

BERNARD L. OSER, Food Research Laboratories, Inc., Long Island City, N. Y.

Proposed legislative restrictions governing the presence or use of chemical agents or additives in foods have drawn attention to the experimental basis for establishing their toxicological potentialities. One can hardly question the wisdom of amending the existing law, which in effect places the burden of proof of harmfulness on the Food and Drug Administration, to provide for placing the burden of proof of harmlessness on the manufacturer. However, difficulties inherent in devising sharp definitions and standards for safety will inevitably impose new strains on administrative discretion. For example, the safety of a food, like that of other environmental factors, is not an absolute concept; thus insistence on "proof of complete harmlessness" is unrealistic. It follows that the responsibility will rest upon administrative shoulders to draw reasonable deductions from the best available experimental evidence.

In drawing practical inferences from toxicological tests designed to adduce evidence for the safety of chemicals in foods, it is important to remember that experimental conditions are so rigid or so exaggerated that many chemicals in current accepted usage would scarcely pass muster. A surprising number of common foods can be shown to have toxic possibilities under certain experimental conditions. The uniform and sometimes arbitrary composition of test diets, the feeding of excessively high dose levels, prolonging the dosage over extended periods or throughout life, and the use of animal species which may respond more sensitively than man, exaggerate toxic effects. Hence there exists an obligation to exercise caution in assessing the possibility of toxicity to man when positive responses are observed in animals. If "necessity" for the use of any chemicals in foods is to be granted, the exclusion of useful chemicals by reason of too severe criteria for safety might not be in the public interest, as broadly construed under the Federal Food, Drug and Cosmetic Act.

On the other hand, negative findings under experimental conditions may only mean that a less apparent manifestation of toxicity has escaped notice. Possible causes for such failure may be the use of normal test animals instead of subjects under some form of physiological stress; differences in species sensitivity; artifically imposed dietary conditions, etc. Hence administrative approval of food chemicals or of tolerances based on even the best current information may be expected always to be subject to reversal or modification as new scientific knowledge develops. A permanent independent board of experts to oversee developments in this field would be in the interest of the food industry as well as the general public.

86. THE APPLICATION OF "END-OVER-END" AGITATION TO THE HEATING AND AND COOLING OF CANNED FOOD PRODUCTS

WELD CONLEY, LAURENCE KAAP, LEO SCHUHMANN, and JAMES RETZER, Research and Development Division, Chain Belt Company, Milwaukee ,Wis.

New equipment has been developed for the heating, sterilization and cooling of foods in sealed containers. Various products have been tested using the new end-over-end principle of agitation. The rapidity with which heat can be transferred to and from canned foods by this method is demonstrated.

A commercial size batch-type machine for 603 x 700 cans, as well as a smaller prototype, were the first machines developed. The construction and method of operation of these is shown.

87. Paper withdrawn after completion of program.

88. FOOD PRESERVATION WITH ANTIBIOTICS: THE PROBLEM OF PROOF

E. J. CAMERON and C. W. BOHRER, National Canners Association, Washington, D. C.

There is no early prospect of using antibiotics for the preservation of canned foods which are presently sterilized with high temperature processing. Thus far no antibiotic has been found that will destroy the typical spoilage organisms that are encountered in canning nor any that will kill *Clostridium botulinum*, the only food poisoning type of importance.

The solution of the problem of proving the adequacy of an antibiotic as a preserving agent calls for collaboration in diverse specialized fields.

Actual killing potency, and not mere inhibition, must be demonstrated on a laboratory basis and the killing effect must include all important spoilage bacteria. The primary requirement must be the destruction of *C. botulinum*.

As the second element of proof, laboratory results must be confirmed by means of inoculated experimental packs and the principles of processing engineering research apply to this phase of the problem. If justified by laboratory results and test packs, a wide variety of test products must be prepared on a semi-commercial scale.

If the preservative effect of the antibiotic is established by laboratory and technological tests, the substance must then be proven to be safe for consumption, toxicologically and clinically.

The problem of proof as applied to subtilin establishes that this antibiotic is notably lacking in the essential requirements for a safe preservative.

89. PRESERVATION OF MILK BY RADIATION

ELMER L. GADEN, JR., ERNEST J. HENLEY, and VINCENT P. COLLINS, Columbia University, New York, N. Y.

A study of the effect of X- and γ-radiations on raw food products has been undertaken. This paper presents the results of work carried out to determine the effects of 2 MEV X-rays on unpasteurized milk. Samples irradiated with dosages up to 1.83×10^6 Roentgen (R) were found to be unaltered in color and texture. No organoleptic changes were detected in samples receiving radiations of approximately 100,000 R and no appreciable reduction in the Vitamin A and B_2 content was observed at these levels. Over 90% of the microbiological population was destroyed with dosages under 50,000 R and storage life of the samples was greatly prolonged.

90. FOOD PROCESSING WITH IONIZING RADIATIONS

BERNARD E. PROCTOR and SAMUEL A. GOLDBLITH, Department of Food Technology, Massachusetts Institute of Technology, Cambridge, Mass.

Research in the last decade has confirmed the possibility that foods and drugs may be sterilized without heat by ionizing radiations.

If laboratory sterilization by this means is to be converted to commercial operations, a number of factors must be taken into consideration, some identical with those in heat sterilization and others entirely different.

The various factors involved in the processing of foods and drugs by ionizing radiations are discussed. Among these are the type of radiation employed, the specific inactivation dosages of radiations, the effects of irradiation on flavor, color,

texture, and nutrients, packaging problems, and dimensions (size and depth) of packages. Consideration is likewise given to the question of the adaptability of radiation processes to presently existing production lines, the radiation equipment needed, and the economics involved.

91. THERMAL DESTRUCTION OF CAMERON'S PUTREFACTIVE ANAEROBE 3679 IN FOOD SUBSTRATES

HOWARD REYNOLDS, ARTHUR M. KAPLAN, FRANCIS E. SPENCER and HAROLD LICHTENSTEIN, Bureau of Human Nutrition and Home Economics, Agricultural Research Administration, United States Department of Agriculture

Cameron's putrefactive anaerobe 3679, has been widely used as a test organism to evaluate process requirements for low acid canned foods. While the thermal resistance of this organism is known to vary with the medium in which it is heated, there are relatively few data in the literature that define the constants of its thermal-death-time curves in food substrates. This report presents thermal-death-time data for P. A. 3679 when heated in 13 low acid foods. Destruction times were determined by processing inoculated food substrates in 208 x 006 enamel lined thermal-death-time cans. Because product inhibition of heated spores incubated in some low-acid foods result in irregular recoveries that tend to obscure the true nature of thermal-death-time curves, destruction times were determined by incubation in the absence and in the presence of medium added as a concntrate to the processed cans. Addition of the medium concentrate, designed to provide readily available nutrients and to adjust the pH of medium-acid products, resulted in more uniform recoveries of heated spores and generally indicated higher apparent thermal-death times. Data are also presented relating to the determination of correction factors for the lethality of the thermal lag encountered during processing of foods in thermal-death-time cans.

92. FACTORS INFLUENCING THE STABILITY OF THIAMINE DURING HEAT STERILIZATION

D. G. HEBERLEIN, L. R. PTAK, G. H. BENDIX, and L. E. CLIFCORN, Continental Can Company, Inc., Chicago, Ill.

The stability of thiamine in four vegetables, peas, corn, tomatoes and lima beans, is presented as a function of time at various temperatures between 220° and 260°F. Reaction rate data are analyzed by the consistency with equation for a first order reaction $K = 1/T \log C_2/C_1$. The reaction rate for thiamine in peas closely follows the first order equation. In corn, K decreases progressively over the 80 minute time interval studied. Lima beans and tomato juice showed a decreasing K value during the first 10 to 20 minutes at elevated temperatures, after which the data were in good agreement with the first order equation.

Addition of phosphate buffers to corn minimizes pH changes which attend thermal processing. Addition of phosphate also improves the constancy of K, but at the same time markedly increases it, thereby indicating that thiamine is less stable in the presence of phosphate.

The effect of pH was studied in tomato juice over a range pH 2.8 to 5.6 at 245° and 260°F. In the presence of citrate buffers, increasing the pH increased K during the initial period at the elevated temperature. This was followed by a decrease in K to a value that was approximately constant within the pH range investigated.

The variability of K during the initial stages of processing suggests that the thiamine molecule undergoes a change to a more stable form when these vegetables are heated to conventional processing temperatures.

93. AN AUTOMATICALLY-CONTROLLED FIVE-CABINET SYSTEM FOR FOOD STABILITY STUDIES

S. BARER, N. H. CEAGLSKE and W. F. GEDDES, Department of Chemical Engineering and Division of Agricultural Biochemistry, University of Minnesota, Minneapolis, Minn.

Five food storage cabinets placed end to end and operating from one refrigerating unit and one dehydrating unit are described in which the temperature and relative humidity can be independently varied and accurately controlled. Each stainless steel food cabinet (capacity 6 cubic feet) is situated within a controlled-temperature enclosure, in which the air temperature is maintained at the desired level by a common cooling unit, individual heating units and by-pass systems. The air coming from the cooling unit is passed into a manifold from which each individual enclosure can draw off air as required, the air being recirculated into a return-air manifold to the cooling unit. When the required temperature is attained, the cool-air supply is automatically shut off and the by-pass system recirculates the air within each enclosure, the air-temperature being increased when required by automatically controlled heaters.

The humidity control system also involves main feed and return lines with individual cooling coils, humidifiers and tap-off systems for each cabinet. While the temperature and humidity of each cabinet can be varied between the limits of 40 to 100°F. and 10 to 95% respectively, the design favors operation of all cabinets at one temperature and different relative humidities. Typical operational data will be presented.

94. INSTRUMENTATION AND RESEARCH AT THE NATIONAL BUREAU OF STANDARDS

WILLIAM A. WILDHACK, National Bureau of Standards, Washington, D. C.

Instrumentation is a common denominator of all physical science, engineering and technology. While the problems of measurement and control are only incidental to the final goal of much scientific research, they are of fundamental importance in the practical methods and techniques of experimental research whereby the final goals of scientific progress are achieved.

The importance of analysis, control, inspection and testing in engineering, warfare, and technology, and the development of industrial, research, and military instruments for these purposes has given rise to an extensive technology of intrumentation and a large instrument industry.

The great multiplicity of instruments developed for scientific research, and the quick application of research instruments to industrial application, have also made it clear that the problems of instrumentation—selection, adaptation, design, development, classification, analysis of operating principles, determination of performance limits, and suitability for specific applications—are quite the same in basic scientific research as in applied technology.

In cooperation with the Department of Defense and Atomic Energy Commission, the National Bureau of Standards has undertaken a program of research and development in basic instrumentation. The scope and content of this program will be described. A brief review will be given of a number of specific instrument development projects, some of which are of potential importance to food technology.

95. PHYSICS AND SPECIAL INSTRUMENTATION

NELSON GILDERSLEEVE, Meter & Instrument Sales Divs., General Electric Co., West Lynn, Mass.

Instrumentation and physics today are inseparably bonded together. The physicist who studied optics, acoustics, electromagnetism, thermodynamics, hydraulics, radiation and spectroscopy, has become the instrument designer using all these principles.

The physicist, and the engineer designing for all industry, measure all these quantities: analysis or composition, color, conductivity, consistency, density, dielectric strength, elastic limit, heat of combustion, magnetic susceptibility, mass or molecular weight, moisture content, refractive index, specific gravity, tensile strength, thermal conductivity, turbidity, ultrasonic absorption, and viscosity. Principles used in these operations will be discussed.

96. UTILIZATION OF INSTRUMENTATION IN THE WET MILLING INDUSTRY

H. C. FROST, Corn Products Refining Company

Important advances have been made in the processing of corn since the end of World War II by the wet milling industry. Instrumentation has played an important part in helping to make these improvements possible. Corn sugar refineries serve as good examples of how instrumentation can be applied to existing batch processes and how satisfactory operation of a continuous process is made possible with automatic controls.

A drying channel for starch is used to illustrate the importance of coordinating through automatic controls the several successive steps in a process. Some examples of unusual applications point out possibilities for expanding the field of usefulness for instrumentation. Of particular importance is a basic new approach to placing information before an operator which will show him the significance of instrument readings with respect to the operation of the process.

97. DISCUSSION OF PREVIOUS PAPERS

Moderator, JOHN R. BOWMAN, Mellon Institute of Industrial Research, Pittsburgh, Pa.

98. MEASUREMENT AND CONTROL OF COLOR IN CANNED TOMATO JUICE

W. B. ROBINSON, J. R. RANSFORD, and D. B. HAND, New York State Agricultural Experiment Station, Cornell University, Geneva, N. Y.

Tomato juice color can be determined with the use of an accurate, objective measurement method. The *a* to *b* ratio of the Hunter color-difference meter serves as an index of color grade when widely different chromaticities are not encountered. When 700 samples were scored by federal inspectors and by the Hunter instrument a correlation coefficient of 0.964 was obtained. Eighty-five percent of the scores agreed within one grade point.

Under uniform processing conditions, the color of canned tomato juice may be predicted from the color of the raw tomatoes. Such a prediction makes possible a control of the trimming operation or a blending of raw material to aid in standardizing the color of the tomato product, or to meet grade requirements.

Color development is influenced by environmental temperature, and during cool seasons internal color development does not keep pace with the external color. For this reason, tomatoes should be picked with a redder skin color during cooler weather.

Plant processes, such as trimming and screening, may be evaluated in relation to their effect on color. As pasteurization temperatures increase the juice color becomes slightly poorer. When juice was pasteurized at 250°F. for 0.7 minute, the preheating temperature used before pasteurization had no effect on color.

99. MEASUREMENT OF THE COLOR OF GREEN BEANS BY REFLECTION

T. W. KETHLEY, W. B. COWN, and F. BELLINGER, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Ga.

The color of green beans in various conditions has been analyzed by reflectance measurements using a Beckman model DV spectrophotometer and reflectance accessory, and employing a rotating disc to hold the sample. The results of these studies indicate that reflectance readings made at 450, 540, and 675 millimicrons give sufficient information for the evaluation of color changes in green beans. These findings may be used as a basis for a more simple objective evaluation of the color of green vegetables.

100. MATHEMATICAL ANALYSIS OF THE REFLECTED COLOR OF GREEN BEANS

T. W. KETHLEY, W. B. COWN, and F. BELLINGER, Engineering Experiment Station, Georgia Institute of Technology, Atlanta, Ga.

Employing data obtained from the measurement of the reflectance of the intact surface of green beans on a rotating disc sample holder, a numerical index has been devised which adequately describes the color changes in green beans caused by maturation, processing, and freezing storage. It has been found that beans cooked for predetermined lengths of time can be used as color standards either for visual or instrumental estimation of color changes in green beans. These findings are directly applicable to the color grading of most green vegetables.

101. OBJECTIVE MEASUREMENT IN QUALITY CONTROL OF FROZEN FOODS

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Subjective tests are usually the basis for in-plant maintenance of quality control. Able and responsible testers can be selected by elimination. Individual evaluations are subject to checking. Sources of discrepencies can be eliminated. However, such

tests are not well suited for public grades and standards. The results may be in-

been frozen in 2 hours and 55 minutes are substantially

tests are not well suited for public grades and standards. The results may be influenced by individual's degree of taste perception, physical and mental state, bias and by other transient and permanent personal idiosyncrasies.

Objective tests are differentiated from subjective tests on the basis that they can be substantially duplicated by trained investigators without appreciable influence by personal variables. While it is rarely possible to comprehensively define the distinctive characteristics of a food solely in terms of objective tests, these must remain the foundation upon which public grading is based. Needless to say such tests are also of great value for in-plant evaluations of quality.

Improved techniques tend to move subjective tests into the objective realm. Mechanical classifications are being developed for such intangibles as color, transparency, tenderness and even for aroma. Among the more important objective measurements for grading frozen fruits and vegetables are:

Total and drained contents of packages; gases in the headspace; hydrogen ion concentration.

Density and viscosity.

Quantity and quality of suspended solids and soluble solids in juices, brines and syrups.

The quantity of such constituents as sugar, salt, starch, protein, acidity, ascorbic acid, fixed and volatile oils, ash and ash constituents.

Texture, resistance to deformation, penetration and maceration.

Enzyme activity, rate of flocculation or settling.

Degree of freedom from contaminants.

Recent developments in relation to objective tests are discussed and the trend toward placing increased emphasis upon eating quality and less upon eye appeal is described.

102. OBJECTIVE TESTING OF VEGETABLES

AMIHUD KRAMER, Department of Horticulture, University of Maryland, College Park, Md.

Substantial advances are being made in the development of precise methods and instruments for measuring quality factors of vegetables. Methods are now available for measuring appearance factors of quality, especially color, where disc colorimetry, and photoelectric transmission or reflection methods may be used. Kinesthetic factors such as tenderness, fibrousness, and succulence may be measured by specific instruments, or by the use of a multi-purpose instrument with interchangeable test cells; or by physico-chemical methods where the objectionable material may be isolated and measured, such as insoluble solids, fiber, or grit. Flavor factors such as acidity, sweetness, salt, or specific off-flavors may be measured by chemical means, while characteristic flavors as well as the accuracy of any objective methods remain in the hands of the taste testing panel whose precision may be greatly enhanced by the use of the statistical designs and interpretations. The objective methods are illustrated with examples on specific vegetables.

103. AN OBJECTIVE METHOD FOR MEASURING THE EFFECT OF FREEZING RATE ON ASPARAGUS

F. A. LEE, Associate Professor of Chemistry, New York State Agricultural Experiment Station, Geneva, N. Y.

An objective test is presented which seems to measure with reasonable accuracy the effects of freezing rate on the texture of thawed and cooked asparagus by means of a crushing action. The results indicate that cooked asparagus spears which had been frozen in 2 hours and 55 minutes are substantially equal in resistance to crushing as those cooked spears which had been frozen in a home freezing cabinet. This test was applied, also, to thawed snap beans which had been previously frozen under various speeds of freezing. Differences in speeds in the crushing of several samples of this vegetable were not observed.

104. EFFECT OF PROCESSING PROCEDURES ON QUALITY OF FROZEN WHOLE KERNEL SWEET CORN

F. E. LINDQUIST, W. C. DIETRICH, and M. M. BOGGS, Western Regional Research Laboratory, Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture, Albany, Calif.

Comparisons were made of the effect of (1) blanching of corn on the cob prior to cutting with (2) blanching of cut kernels on the quality of frozen whole-kernel sweet corn. The Golden Cross Bantam variety was used throughout. Harvests were made at four stages of maturity (moisture content ranging from 63 to 77 percent). Samples were prepared from each harvest lot by six processing procedures and subsequently frozen. Chemical analyses of the frozen samples, which included moisture (total solids), alcohol-insoluble solids, and total sugars, showed that, on a per-kernel basis, material blanched on the cob had greater amounts of these constituents than did kernel-blanched material. In like manner, the yield of processed material was greater when the cob blanching procedure was used. Color analyses carried out by recording spectrophotometer and reflectometer showed differences due to maturity but no consistent trends due to processing procedure within any given maturity group. The samples from each maturity group were appraised separately by a panel of experienced judges. After six examinations, the replicate mean scores were analyzed for significance by analysis of variance. In all cases, cob-blanched samples received significantly higher flavor scores than did samples blanched as cut kernels.

The data obtained indicate that blanching on the cob is the method of preference for processing whole kernel sweet corn. This procedure yields a product of higher flavor quality in greater yield and is readily adaptable to simple line operation.

105. BROWNING OF FROZEN VEGETABLES, PARTICULARLY OKRA

J. G. WOODROOF and ETHEL SHELOR, Food Processing Department, Georgia Agricultural Experiment Station, Experiment, Ga.

As high as 25 percent of consumer packs of one brand of frozen okra was found to be very brown and tasteless while other packages in the same cases and packed at the same time were bright green with excellent flavor. A series of experiments in the laboratory and in processing plants showed that: (a) the browning occurred within a few minutes or hours after blanching, and became slightly worse during freezing storage; (b) browning was in no way related to the rate of cooling after blanching, nor the interval between blanching and freezing, or to the rate or method of freezing; (c) it was found to develop during or immediately after blanching when the blanching temperature was allowed to reach 160-176 degrees; (d) blanching in water or steam at temperatures below or above this range failed to cause browning and loss of flavor. Certain other vegetables behave in a slightly similar manner, and are being studied.

106. EFFECTS OF FREEZING ON TENDERNESS OF BEEF FROM DIFFERENT MUSCLES AND FROM ANIMALS OF DIFFERENT AGES

RICHARD L. HINER, Bureau of Animal Industry, Agricultural Research Administration, United States Department of Agriculture

This study was undertaken to determine if the freezing of beef samples representing different locations within the beef carcass tenderized all of them to a significant degree. Nine paired samples representing nine different cuts from each side of 52 beef animals of various ages were used. One sample of each pair was tested objectively for tenderness. The paired material was placed in a 0°F. freezer and frozen in still air. After freezing, the samples were removed, thawed at 45°F. and tested in a similar manner for tenderness. Only in the sample representing the foreshank did freezing have no significant tenderizing effect. On the other hand, in all age groups, except the veal calves, the sample from the round was the only sample that was tenderized to a "very highly significant" degree by freezing. The samples from the 16-month-old steers were tenderized more by freezing than those of any of the other age groups: in 7 of the 9 samples the differences were "very highly significant" and in the 8th it was "highly significant." All samples except the foreshank from cows, barren heifers, and 500-pound steer calves were tenderized to a "significant" or "very highly significant" degree. The samples from veal calves showed some tenderizing effect but it was not statistically significant except for the loin end. An analysis of variance showed that increases in tenderness were highly significant between age groups, whereas those between samples within the same age group were not.

107. A SURVEY OF PROCESSING METHODS USED IN FROZEN FOOD LOCKER PLANTS

C. F. DUNKER and O. G. HANKINS, Bureau of Animal Industry, Agricultural Research Administration, United States Department of Agriculture

Questionnaires sent to 11,074 frozen food locker plants concerning methods used in the processing of meat, revealed that 93 percent freeze meat, 73 percent store cured meat, 38 percent dry cure and 27 percent brine cure meat. Ultraviolet lighting is used in the chill and aging rooms of 49 percent of the plants. Freezing is carried out by air blast, contact, or in still air at −10°F. to −20°F. for 24 hours, after which the meat is stored at 0° to −5°F. for a period of 3 to 12 months. During freezing and storage the meat is protected by wrapping in special waxed locker paper, in cellophane, in aluminum foil, in laminated paper, or in a combination of these, using a single or a double wrap. Typical curing consists in pumping hams or shoulders to 10 percent net weight, followed by either brine or dry curing for 1 to 2 days per pound of meat. Usually commercial preparations are used. After curing the meat is washed, smoked 8 to 24 hours, wrapped in various types of paper or foil, and stored 3 to 12 months at locker room, chill room, or ordinary room temperatures. Sixty-four percent of the operators reported less than one percent of cured meat is lost due to spoilage, and that pumped meat is less susceptible to spoilage than is unpumped meat. Frozen food locker plants freeze veal and lamb, and both freeze and cure pork and beef.

108. PREPARATION OF STABLE FROZEN SAUCES AND GRAVIES

HELEN L. HANSON, AGNES CAMPBELL, and HANS LINEWEAVER, Western Regional Research Laboratory, Albany, Calif.

Precooked frozen sauces and gravies thickened with wheat flour show "separation" (curdled appearance) when thawed for use. Methods of preventing this separation by using other starches, flours, and commercial stabilizers have been studied. Although tests have shown some improvement in the frozen storage stability of the sauces with several of approximately 60 such experimental products, waxy (glutinous) rice flour was outstanding in all respects. In flavor and appearance unfrozen sauces prepared with waxy rice flour are difficult to distinguish from those prepared with wheat flour. When sauces thickened with the waxy rice flour were stored for 5 months at 0° F., they could not be distinguished from the freshly prepared unfrozen product. With wheat flour, the separation was observed even when the product was thawed immediately after freezing and became progressively worse with prolonged storage. Storage results under varying temperature conditions for periods as long as 12 months will be presented.

109. INFLUENCE OF STORAGE CONDITIONS ON FROZEN AND CANNED APPLE JUICE CONCENTRATES

C. C. NIMMO, L. H. WALKER and VIRGINIA S. SEAMANS, Western Regional Research Laboratory, Albany, Calif.

In two separate experiments, apple juice concentrates, with single-strength juice as controls, were packed for frozen storage and for room temperature (75°F.) storage. Sanitary cans were used throughout, except for one pack in glass. Original flavor and color were well preserved in storage at 0°F. for 12 months. The samples kept at room temperature showed definite changes in flavor and color after three months' storage, and were judged to be of very poor quality after twelve months. Difference between concentrates packed cold for freezing and those hot-filled by flash pasteurization were found to be insignificant or unimportant in the first few days after packing. No important differences were observed between single-strength and concentrated juices. Iron content of the samples, accumulated in certain cases from can corrosion, was apparently not an important factor in producing flavor and color changes.

110. CONSUMER TRENDS IN NEW FOOD PRODUCTS FOR HOMEMAKERS

A. A. SCHAAL, Good Housekeeping Bureau, New York, N. Y.

A new and desperate trend has besieged the homemaker—the need to stretch money in buying food. This need may have to transcend quality, nutritional requirements, convenience and other facets of the family feeding problem. Money in the food budget has been running out and will continue so in this defense age. Next to this economic pressure comes the time saving in food preparation and the opportunity of pleasing the family most by simpler substantial foods, perhaps lacking in some of the artistry that prevailed in years past when time and money were more abundant. The consumer wants better packaging, more informative labels, greater surety on the cleanliness of foods and on their ability to meet any special dietary problems.

She is exceedingly appreciative of truthful advertising, whether by print, radio, or TV, and of honest effort to help her serve more nutritious, more satisfying and more tasty foods. She continues to acquire more education on foods by way of the advertising pages than by any other media; and since the essence of education is truthfulness, she naturally longs for honest statements by the food manufacturer.

The consumer is steadily demanding that food suppliers do more and more of both her work and her planning. They can shorten food preparation time, suggest

dishes and even menus around the can or package, and help her greatly to keep her

dishes and even menus around the can or package, and help her greatly to keep her individuality as a cook by variations and seasoning accompaniments. Never have food manufacturers had better prospects for thriving.

111. NEW FOODS FOR INSTITUTIONAL USE

PAUL B. LOGAN, Director of Food and Equipment Research,
National Restaurant Association

The rapid rise in the price of foodstuffs during the past year and steadily advancing labor costs, point to an important need for more rapid development of food products which are fabricated, processed, treated or packaged in a manner to provide more accurate control by restaurants over inventories and portions, or which will serve to reduce labor costs. In a well-managed restaurant, food cost will not exceed 46% of the sales dollar and labor not over 28%. Overhead will average 22 to 25% which makes it obvious that for profitable operation food and labor costs must be kept below 75%.

The best approach to the reduction of labor costs is through the supply of partially prepared material, such as commercially peeled apples and potatoes, frozen fruits and vegetables, frozen concentrated fruit juices, fabricated meats, poultry and fish, and prepared mixtures for baked goods. A striking example is frozen orange juice concentrate which has reduced both food and labor costs in restaurants. The restaurant industry will benefit greatly from the use of fabricated meats. Similarly high quality frozen eggs for table purposes would be an important development. A high quality spray-dried milk powder, prepeeled, and pregraded potatoes, high quality frozen fish fillets, frozen, canned, or dehydrated apples with fresh apple flavor for pie making, premixes for bakery goods, and better methods of handling fresh produce from harvest to consumer are examples of fields which need exploration. Since about a quarter of all of the food consumed is served in restaurants, this area of research is particularly important.

112. NEW FOOD PRODUCTS NEEDED BY THE ARMED FORCES

HOWARD D. LIGHTBODY, Quartermaster Food and Container Institute,
Chicago, Ill.

The Armed Forces have special needs for new food items which meet the requirements of men in action: (1) on the ground where preparation for serving is non-existent or limited to the application of heat and, under some conditions, to heat derived from fuel carried on the person, (2) in the air on missions which require several hours to perform and in atmospheres which necessitate oxygen supplementation, (3) on board ships where space provided for food may be secondary to other requirements, and (4) under conditions of survival where resupply or subsistence on food obtainable from the environment is impossible.

The economy of space and weight is a major goal. This means greater use of dehydrated items, and the associated problems of rehydration. Rapid rehydration would extend uses to small operating groups and also to individuals.

In practice the present storage life requirements are somewhat elastic because of compromises between needs and technical feasibility. Greater stability is an almost universal need. Foods more resistant to rancidity, staling, browning, and protein structure disintegration when stored at tropic temperatures for many months are needed. Physical changes accompanying either tropic or frigid temperature storage are problems of spreads for bread and of some confections. Canned meats, without canned meat taste and retaining the natural texture, would contribute markedly to ration acceptance. New carriers for some of the vitamins are needed in order to assure adequate intakes by individuals who because of food habits refuse to consume vitamin-rich items.

113. DIETETIC FOODS

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American Medical Association, Chicago, Ill.

In this paper it is proposed that the purpose and definition of "dietetic foods" be discussed from the point of view of the physician and his patient.

114. SOME PRACTICAL PROBLEMS IN THE INTRODUCTION OF NEW FOOD PRODUCTS

FRANKLIN C. BING, Consultant, Chicago, Ill.

Food technologists generally are aware of the multiplicity of problems concerned with the introduction of new food products. From the initial idea to the finished product on the tables of consumers there are questions involving raw materials and other ingredients, production, packaging, storage, labeling, distribution, shelf life, and advertising to be considered and answered. There are technical aspects to all phases of operation. Some of the practical problems demanding attention in the initial planning and in the final marketing of the product are sometimes not given the technical consideration which they should receive. Mention will be made of some of these practical problems and examples cited.

115. NEW DEVELOPMENTS IN MEAT PRODUCTS

H. R. KRAYBILL, American Meat Institute Foundation,
University of Chicago

A number of new or improved products developed in the last several years will be discussed briefly. Meat food shortenings have been developed which are excelled by no other shortenings. The development of suitable antioxidants has made it possible to impart high stability to the meat food shortenings. Although earlier experiences in marketing frozen meats were not too successful, in the past few years the industry has been marketing successfully frozen hamburgers, sandwich steaks, veal cutlets and similar items.

An eight- to ten-ounce liver sausage packaged in a transparent plastic film has met with very favorable acceptance. The product has excellent storage and refrigerator life with little or no color, flavor or nutritional deterioration when displayed under normal refrigeration. Improvements in prepackaging of ready-to-eat meats have been made including vacuum packaging of some items.

A boneless veal roast dipped in a fat emulsion has been developed and marketed successfully.

In the pharmaceutical field ACTH, cortisone and crystalline trypsin have been developed on a commercial scale, ACTH and trypsin by members of the meat industry and cortisone by pharmaceutical companies from the bile collected by the meat industry.

116. PARTIALLY BAKED PRODUCTS

THOMAS FREER, General Mills, Inc., Minneapolis, Minn.

The partial baking of commercially produced yeast raised goods assures maximum freshness at time of consumption. This is achieved by the final browning of

pre-processed baked foods in the home. Initial processing is exclusively a commercial bakers' technique.

Mr. Joseph Gregor of Avon Park, Florida, originated the partial baking process. He accidentally noted that yeast raised rolls prematurely removed from his bake oven before browning (or crust coloration) retained their normal shape after cooling. These rolls were normal in every respect after additional baking to the point of desired crust color. He reasoned the latter phase might best be done in the home immediately before serving, thus solving a major commercial bakers' problem of reducing the time lapse from out-of-oven to table-consumption.

Gregor's observations have been extensively investigated in the laboratory, and the knowledge gained given to the commercial baking industry. Application has been made to a wide variety of baked products. Within two years this has become a widely accepted baking practice.

Some of the formula revisions required together with processing methods will be described.

117. NEW DAIRY PRODUCTS

LLOYD K. RIGGS, National Dairy Research Laboratories, Inc.,
Oakdale, Long Island

Some new dairy products are simply old products in new commercial forms. For example, milk which is concentrated to three times its normal solids content and sold fresh, has been marketed for only a few months. This product is made possible by the strictly controlled application of low-temperature evaporation. On account of its high-solids content, this product keeps better (three to five weeks under refrigeration) than pasteurized milk. The equivalent of a gallon or two of milk in this new form can be readily stored in the household refrigerator, and when reconstituted with two volumes of water, it yields a product similar in all respects to fresh, pasteurized, homogenized, vitamin D milk.

Another example is sliced cheese. In general, this product is not sliced at all, but is molded into slabs of sandwich size and packed in convenient household packages.

Another way in which a new dairy product may be developed is by changing the ratio of the constituents of milk. An example of this type of product is a non-fat milk powder which contains approximately twice as much protein as does non-fat milk solids. This product is on the market in only a limited way, largely to hospitals for special dietary use. It is also useful as an ingredient of manufactured dairy products.

A new dairy product may result from the removal of one or more constituents from milk. Low-sodium non-fat milk solids is a product from which some 98% of the sodium has been removed, either by dialysis or by ion-exchange procedures. This product is a valuable addition to the diet of hypertensives and others who must live on a diet low in sodium.

A new dairy product may result from a combination of technical treatments. For example, a high-protein low-salt non-fat milk powder is a useful product for special dietary use.

The lactose of milk may be split by lactase into its constituent simple sugars. Either skim milk or whole milk thus treated may be used to increase the milk solids content of ice cream without producing sandiness due to lactose crystallization.

118. RECENT ACTIVITIES IN CANDY RESEARCH

PHILIP P. GOTT, National Confectioners' Association

Through the National Confectioners' Association cooperative research project with the Department of Agriculture, the following activities have been recently developed:

A variety of candies suitable for use in operational rations of the Armed Forces have been made and submitted to the Quartermaster Food and Container Institute for evaluation. These consisted principally of bar type combinations cast in disc form and coated with summer chocolate coating. Bar confections of high nutritional value suitable for survival type rations were developed and submitted to the QM.

A variety of experimental candies were made with approximately 20 percent of a commercially available grade of whole milk whey incorporated as a dry ingredient. This ingredient was particularly suitable for use in a cast caramel.

Increase in calcium content of candies cast in mixtures of calcium carbonate and starch was studied, and resulting data submitted to the Food and Drug Administration. As a result the Administration has stated that there will be no objection to use of such mixtures or to resulting increase in candy's calcium content.

Evaluation of antioxidants for use in fat-containing candies, particularly with respect to stabilization of butter, has given indications of the relative values of different antioxidants. Tests were completed with seven different antioxidants used in butter caramels. Experiments indicate importance of freshness of butter used in candies, as butter deteriorates slightly under best storage conditions even though a fairly high score may be maintained. Butter, after a month's refrigerated storage, will develop rancidity more rapidly than freshly churned butter.

119. WHAT'S NEW IN FROZEN CONCENTRATES

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U. S. Department of Agriculture, Washington, D. C.

The success of frozen concentrated orange juice has led to greatly increased interest in and production of various other frozen-food concentrates, including grapefruit, lemon, tangerine, grape, apple, and tomato juices, and milk and coffee. These products all reflect consumer demand for processed foods of superior quality and increased convenience in preparation for the table.

Methods used for production of frozen citrus-juice concentrates have not proved wholly satisfactory for making certain other concentrates, notably from apple juice. A modified procedure that appears promising for apple-juice concentrate involves recovery and return to the product of volatile apple-flavor essence. In the case of frozen concentrated tomato juice, precooking of the tomatoes may prove desirable.

Progress is being made toward production of an attractive frozen concentrated juice from pink grapefruit. The advantages to be gained through development of a method for recovery of citrus-fruit flavor essences are such that, in spite of previous failures to obtain satisfactory citrus essences, there is a need for additional research in this field.

Partial dehydration and freezing of fruits and vegetables offer additional possibilities in the frozen-concentrate field. Examples of products of this type include "dehydrofrozen" apples and peas.

120. NEW PRODUCTS FROM CALIFORNIA CLING PEACHES

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During the past twenty years canning cling peaches have been in surplus frequently and much of the crop in some years is arbitrarily dumped to limit output of the canned. Experiments conducted to devise and develop new products that might utilize some of the fruit in years of surplus have resulted in several promising products. One of these is a canned cling peach sauce prepared much as is canned apple sauce. Another is julienne strips canned in medium syrup for use in salads, pies, gelatin desserts and such. Another is sieved peaches lightly sweetened for use in ice cream, milkshakes, puddings, etc. Crushed peaches also have merit and are made by coarsely grinding, addition of one of sugar to six or seven of fruit, heating and canning.

Product Control in the Baking Industry[a]

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(Manuscript received May 29, 1950)

A discussion of the various factors that contribute to successful products control in bakery operation is given. Organization set-up, department responsibility, and the mechanics of material and products inspection are covered.

Successful product control in a bakery operation is essentially the same as in a packing plant or a shoe factory or a steel mill. An attempt will be made below to point out some of the items which we occasionally over-look when we think of "Product Control." Too often we visualize only the office or department that concerns itself with testing supplies and products.

I wish to suggest that efficient product control involves team work of high precision from administrative head down through Purchasing, Personnel, Production, Laboratory and Merchandising. When all departments are carefully integrated and balance is achieved all along the line, then the confidence which team organization inspires brings out the best efforts of each group. Under this type of organization there is no place for prima donnas.

At the top, administrative authority makes policy decisions after considering the recommendations of the various department heads. The merchandising department must be considered in problems of consumer demand, package appearance, seasonability, timing, and advertising. The production department can offer counsel in matters pertaining to costs and equipment limitations. The purchasing department is qualified to offer guidance in problems of procurement, costs, and availability of supplies. The laboratory should provide specifications arrived at by a knowledge of the requirements of the manufacturing department.

No new product should be offered for sale until all of these functioning elements of the team are in sustantial agreement as to the feasibility of the proposal. Once agreement is reached, then each member of the team can operate smoothly and with clearly defined purpose.

I know that the thought that suggested the title to this discussion considered "Production" to be the theme, so, therefore let me confine these remarks to some of the details which pertain to the functions of the three persons most intimately connected with manufacture, namely, the purchasing agent, the supervisor of production, and the laboratory head. It is of utmost importance that these three offices work together cooperatively and harmoniously.

What the production department needs is ingredients best suited to the manufacturing problem. The laboratory is prepared to draw specifications after thorough tests. This can best be accomplished if the head of production is always available for consultation so that decisions will be the result of complete understanding of all of the needs. For example, we may consider the problem of writing specifications each year when the new crop flour becomes available. The mills quite generally strive to mill the new wheat so as to obtain flour having the characteristics which pleased the baker when he used the flour of the previous crop. However, it is frequently necessary for the bakery laboratory to require adjustments in maturing treatment, bleach, etc., to meet the special requirements of the production department. To accomplish this purpose, the laboratory consults with the mill concerning these factors as well as concerning the maltose level, ash, etc., and finally by joint effort a specification is agreed upon which produces laboratory results satisfactory to the man responsible for shop production. In this manner confidence is established in the minds of those who will be charged with product results.

The purchasing department, having clear specifications to work with, will maintain a steady flow of flour to the plant and if the flour remains constant in character all will be well. The laboratory has the responsibility of checking each shipment of flour to determine if it is up to standard in analytical character as well as in baking performance. Where the laboratory, mill, and production departments function properly the flour problem is a minor one; this applies to both cake and bread.

When such careful control of ingredients is extended to the whole supply of materials, then one vital phase of control has been accomplished. There is left the problem of utilizing the ingredients to the best advantage. The chief of bread or cake production knows how to use his ingredients to the best purpose but to accomplish sucessful usage depends upon the active participation of supervisors, superintendents, foremen, and journeymen. Education, training, and careful supervision at all stages are essential if the manufacture of a uniform product is to be achieved. This is the lubrication for a smoothly functioning production line. In an operation that involves multiple units, there is a definite need for one or more production supervisors who are responsible for the guidance of the plant superintendents. Such men will serve to disseminate the instructions from headquarters and at the same time personally counsel the plant superintendents in means to accomplish the general office instructions. Where personnel training is given plenty of attention, the road is clear for understanding to be transmitted all of the way down to the last man in the production line.

A similar type of effort by the engineering department is essential if efficient machine operation is to be attained. Without trouble-free functioning of motors, ovens, wrapping machines, refrigeration equipment, etc., there is no possibility of successful product control.

Assuming that we have facilities to govern the actual production, then we may consider some of the factors that are less obvious in the consideration of successful control of products. The purchasing department and

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the laboratory carry considerable responsibility for the efficiency of production; these departments must work together closely if suitable materials are to be available at all times. Wrapping paper that is weak, is deficient in wax, or uneven in color may cause excessive processing waste; the wrong quality of ink may harm or ruin cake boxes or bun trays due to the odor of ink solvent being absorbed by the product. The best production effort is in vain, should the cards that the cakes stand upon be of such nature that sulphite or other objectionable odor is given off.

To avoid interruptions in the steady production of products of standard quality and acceptability, it is essential that the laboratory and the supply department should determine sources that can control board or paper quality and then confine purchases to such accepted sources. This is but an example out of a multitude of supplies that must be closely controlled. Some materials are more susceptible to variation in quality than others; among such may be mentioned shortening, dairy products, flavoring materials, etc. They are less stable in keeping properties and vary to a greater extent than items such as sugar, salt, and the like.

It is the responsibility of the laboratory to watch the quality of all ingredients that are supplied to the plants. Even slight variations from standard quality or character must be reported to the purchasing department as promptly as possible so that proper steps may be taken to correct the fault. At times a shipment is received that is so far off from standard that it must be refused but at other times it is possible that a minor deviation from specifications may be met by shop adjustment. In the latter case, the chief of production is advised of the identity of the shipment and he can authorize a compensating change in the shop routine. With this information in the hands of the shop superintendent he can meet the situation with confidence and no variation in the quality of the baked products will occur.

Lest one draw the conclusion that attention to ingredients is the whole problem, we should point out that many incidental supplies have a very direct bearing on the smooth functioning of the bakery operation. For example, to insure the best operation of the divider, it is necessary to have a particular grade of divider oil: to avoid oven explosions the fuel oil must meet definite specifications. The label adhesive is subject to variations which may cause labels to pop off when dry or make them curl up in such a way as to make the package unsightly. Each lot of adhesive should be tested.

To meet the responsibilities of proper supervision of incoming supplies, the laboratory usually resorts to less than complete analysis of materials for control work. Specific gravity and flash point may be sufficient for fuel oil. Color and flavor will suffice for cocoa inspection, and color and granulation will be satisfactory for sugar. On the other hand, flour, some types of shortening, milk, syrups, etc., can only be tested for acceptability by means of the baking test in addition to certain chemical tests.

Because the baking test is so vital in control work, it is essential that the laboratory personnel in a bakery should include the services of experienced and expert bakers. The baker must have facilities to bake with a precision that will yield identical results on a given flour at successive bakings. Such a baker must be able to interpret deviations in bread quality in terms of ingredient deficiencies. A good operator will be able to translate the results of the baking test into shop practice. Working under conditions that permit him to consult with the production chief tends to keep the operator alert. The confidence of the production department in the laboratory is based on the reliability of the results which it receives.

The well operated laboratory will in a sense actually "tailor" the supplies of ingredients in such a manner that the products of many suppliers will be almost identical in working character. When that is accomplished, differing brands of milk, flour, cocoa, etc., will be available for selection by the purchasing department with the result that shop adjustments will not be called for.

There is a phase of the problem of producing uniform products of high quality that bears heavily on the management. I refer to the policy of providing equipment and facilities which assure superior products. If management desires that the output be uniform in character, it must face the fact that no amount of planning, thought, or supervision will attain the objective if pans are misshapened or dented, if the divider is worn out, or proof boxes are inadequate or inefficient. Every poor piece of equipment from mixer to wrapping machine is a hazard to quality and uniformity. In a field that is as competitive as the baking business, obsolescence must be recognized promptly if quality is to remain competitive.

Careful cost accounting contributes much to sound planning for replacement of equipment. It may be well to cite an example. Bread and cake pans have a life that is limited mostly by the handling which they get. Inefficient greasing equipment leads to dumping abuse and this results in cripples. Improper washing procedure may remove tin and that induces rust. Both of these factors may cause high losses due to cripples. When the cause is determined, one finds that an expenditure may be justified for new greasing equipment or a new washer. The auditor will determine what the cost of cripples may be and balance such expense against the price of machine replacement and find that the production department is warranted in requesting new machines. This is but an example of how co-operation between departments makes possible an orderly supervision at management level.

I would like to turn now to another element of control effort. This concerns the means which may be resorted to in order to evaluate the finished product. If one stops for a moment to think, he will realize that there must be some point in the general plan where achievement is measured against planned intent. In many cases the product control department is called upon to evaluate production results. This department must watch the production line to determine if all of the factors that denote quality are at par. In many cases in the baking industry, an independent institution is called upon to make this decision; in others the company product control unit is responsible. It is basically a process of appraising the various factors that contribute

to the perfect product. It is essentially a process of rendering a numerical score that will indicate how closely a sample approaches the ideal of the management. Such a scoring system, if accomplished with careful attention to detail and that detail expressed in the terms of the score, will serve to indicate the source or cause of the penalties. This is valuable in several ways; it will indicate to the chief of production what error of manufacture is present in the shop operation, or if the fault appears persistently in spite of efforts to correct it, then it may serve as evidence that a change is needed in equipment or personnel.

When administrative officers, merchandising executives, and production chiefs together make it a point to view the products regularly, the function of scoring is of great help in solving problems that cause less than good bread or cake. Such an arrangement is a potent factor in achieving a high degree of control.

It may be well to point out that the usefulness of a scoring system is dependent upon the organization plan. The department that scores the efforts of other departments must not be subject to the authority of any other department that may be affected. A further comment is that the person doing the scoring should know the manufacturing process intimately for then his scoring comments may well serve to guide the man in charge of the plant operation in his efforts to correct the faults observed.

In some organizations the product score is transmitted to all of the departments involved in production; in other cases it goes to administrative officers only. It may be said that a scoring system that is detailed will generally be useful to manager and superintendent and will be advisory to the administrative head.

Careful integration of the efforts of departments whose functions are dissimilar is essential to good control of products quality. A meeting of minds at top levels of authority makes for consistent coordination of ideas, equipment, and personnel effort. Specialists of several kinds must work together with mutual understanding of the main objective and in a cooperative effort to achieve the optimum in character and uniformity of product. When good team work is attained then good results are to be predicted.

Keeping Quality of Precooked Frozen Chicken a la King, a Bacteriological Evaluation of Hot and Cold Packs[a]

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Data on the stability of precooked frozen chicken a la king, adequately processed and carefully handled, under both commercial and simulated military storage, are presented. The bacterial population, pH changes, and organoleptic qualities are reported at selected intervals on commercial-scale batches of the product prepared by the hot pack and the cold pack methods. Results of this study show that the process of hot filling followed by quick freezing at 0° F. (—18° C.) assures a virtually sterile product after a storage period of two months, with no significant change in count during a year of storage. The cold-filled product was also shown to be highly satisfactory. However, a somewhat higher bacterial count, ascribed to post-contamination during handling prior to the quick-freeze processing indicated that sanitary handling and speed are essential to manufacture of a wholesome product. Acceptability of both products was initially high and remained substantially unchanged by a year of storage.

Frozen foods which have such wide acceptance by the civilian consumer also have great appeal for military personnel both for domestic and overseas feeding. Frozen foods enhance the ration, reduce the time and labor of food preparation at the point of consumption, conserve strategic metals, and save shipping space. Fresh frozen meats, fruits, and vegetables were successfully used during wartime and great quantities were procured by the Armed Forces for both garrison and field rations. The successful use of fresh frozen products doubtless inspired interest in precooked, ready-to-serve foods, of which chicken a la king is a representative item.

Experimental work on the freezing of precooked food was undertaken early in the war. By the end of the conflict, one organization, the Naval Air Service, was being supplied with such products regularly. By 1945, the food processors were also evincing a strong interest in frozen precooked foods, and more than a hundred items were available on the civilian market.

Little of this product was laboratory-controlled at the beginning of this industry, and bacteriological examinations and storage investigations were few and inadequate. No data on bacterial growth, for example, had been assembled on the storage of frozen products. It is now recognized that the storage conditions then available for overseas shipments (both rail to shipside and aboard ship) were not suitable for products requiring temperatures in the range of 0° F. (—18° C.). Notably lacking were studies on the handling of frozen foods at interrupted points enroute. Reports during the war from one overseas station, where a substantial quantity of precooked frozen meals was stored, indicated high bacterial counts in many of these products. In some products the presence of *Salmonella* organisms

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was also observed. Overseas shipments frequently showed evidence of defrosting; in fact, the records indicated that temperatures in the hold ranged at times up to 32° F. (0° C.), manifestly too high for the safe-keeping of frozen foods.

More data have become available since 1946, when this work, using chicken a la king as a test item, was started. Reports *(1, 2, 3)* directly pertinent to the bacteriological quality of precooked frozen foods, including chicken products in creamed sauces, have appeared. A survey of precooked frozen foods by Proctor and Phillips *(1, 2)* has indicated that plate counts for most samples of such products ran between 10,000 and 50,000 per gram. Plate counts for chicken a la king averaged 46,000 per gram and chicken chow mein showed a count of 23,300. Tests by Gunderson and Rose *(3)* on commercially produced chicken chow mein stored for periods as long as five months showed plate counts between 20,000 and 25,000,000. All of these investigators stressed the need for adopting sanitary production methods in order to market a bacteriologically acceptable product.

The present study was initiated in order to obtain data on safety factors of precooked frozen foods and to determine the stability of such foods under both commercial and military storage. Data at selected intervals were collected on the bacterial population, pH changes, and organoleptic qualities of one product, chicken a la king, which was chosen, because of its suitability as a substrate for the growth of bacteria.

EXPERIMENTAL

Description of Chicken a la King Manufacture

Commercial-scale batch operations were employed in this study, and precautionary sanitation measures were conducted under the supervision of bacteriologists. Since mechanical equipment was not yet installed for conveying, filling and packaging, these operations were carried on by hand. For the filling operation, hand ladles were used.

Two intermediate products were necessary for the manufacture of chicken a la king, viz. (1) diced, cooked chicken meat, and (2) a white sauce containing green peppers, pimientos, seasoning agents, sautéed mushrooms, and chicken stock. Details of these preparations and of the two methods of mixing for packaging are given below.

Chicken Meat. Grade A, New York-dressed chickens weighing 5 to 6 pounds each and hard-chilled for 17 days after killing were used. Two days before cooking, the fowl were eviscerated and prepared for cooking and stored in a 40° F. (4° C.) refrigerator. The fowl were cooked in salted boiling water. After being boned, the meat was cut into small slices and chunks. No skin, liver, gizzard or hearts were used. Two consecutive batches of cooked chicken were prepared and pooled.

The cooking procedure for the first batch was as follows: One charge of 62 fowl and 30 gallons of salted water was introduced into a pre-sterilized steam-jacketed stainless steel kettle and brought to boiling in 37 minutes. The cooking was maintained at the boiling point for 120 minutes after which the chickens were transferred one by one to stainless steel work tables where they were immediately boned. After the boned chickens were hand sliced, the chunks were placed in stainless steel trays. The last fowl was removed from the kettle 90 minutes after the boning operation started. The cut-up chicken meat, covered with sterile towels, was held in a refrigerator at 46° F. (8° C.) while awaiting the completion of the white sauce.

The second batch was cooked as follows: A second charge of 42 birds and 20 gallons of salted water was started simultaneously and was treated in a similar manner. For the somewhat smaller charge, 25 minutes were required to bring the batch to cooking temperatures and after a 2-hour cook, the boning and cutting operation covered 55 minutes. The second batch of chopped chicken meat was refrigerated in the same manner as the first batch.

White Sauce. The liquors in which the fowl were cooked were concentrated by simmering, the volume thereby being reduced approximately 12 percent. This rich extract of soluble matter from the meat and bone was used as the chicken stock component of the white sauce. To prepare the white sauce, a roux of melted butter and flour was blended with a small portion of the chicken stock. In another vessel, stems and pieces of canned mushrooms were sautéed and added to the mixture. A further addition of pimientos, fresh green peppers, white pepper, salt and mace was made, and the entire mixture was cooked for 45 minutes. To the remainder of the chicken stock, the concentrated sauce was added and the melange was boiled for 15 minutes to yield about 35 gallons of a white sauce.

Blending and Packaging. Two variations in packing procedures were studied: (1) a hot-filled product and (2) a cold-filled product. The hot white sauce was divided into two equal portions. One portion was reserved for the cold pack together with one-half of the chicken meat. The remaining chicken meat was reserved for the hot pack. The packaging material consisted of moisture-vapor barrier cellophane bags (450-MSAT-87) which could be sealed by a hot iron and outer cartons of blending chipboard (0.023 inch thickness). The outer facings of the carton were manila lined and the inner facings were lined with a laminated parchment (0.0003 inch thickness). Details of the filling and packaging procedures follow.

For the hot pack, the chopped chicken meat was thoroughly mixed with hot sauce in a stainless steel vessel and the mixture heated for 10 minutes at 212° F. (100° C.). For convenience in the filling operation, the heated batch of chicken a la king was dispensed from two 15-gallon aluminum pots which had been placed in the deep wells of a steam table. Two hundred 1-pound packages of the product were filled by hand-ladling. The cellophane bags were then heat-sealed and each package was code-marked by hand. The entire operation required only 33 minutes. At the filling point the product was maintained at a satisfactory temperature by the use of the steam table arrangement. The temperature of the first package at filling was 212° (100° C.) and that of the last (200th) package filled, 189° F. (87° C.).

For the cold pack, the hot sauce (212° F.) was rapidly cooled to 55° F. (13° C.) and the chilled chicken meat was added. The cooling of the sauce was conducted in a pre-sterilized stainless steel cooling vat equipped with a jacket through which a cold brine solution (27° F.; —3° C.) circulated to effect the heat transfer. Agitation of the sauce, intermittently applied, increased the rate of cooling. A temperature of 55° F. (13° C.) was reached in 135 minutes. Inspection of Table 1 will show that the temperature of optimum growth of all pathogenic organisms was passed with sufficient rapidity to prevent proliferation.

TABLE 1

Rate of Cooling of Sauce

Time (minutes)	0	15	30	45	60	75	90	105	120	135
Temperature (° F.)	212	154	128	108	92	77	68	64	56	55

The well-mixed cold blend of chicken a la king was packaged, sealed and coded by hand in the same manner as described for the hot pack. The temperature of the product as filled was 55° F. (13° C.) or lower. Two-hundred 1-pound cartons were cold packed in 57 minutes.

Plant Sanitation. The manufacturing conditions with respect to raw materials and ingredients, equipment, and working area were examined bacteriologically, and routine precautionary measures were established.

The raw ingredients used were of top quality grades. The absence of thermophilic organisms was shown in the spices (white pepper, salt, and mace) and in the flour. The mushrooms and the pimientos were canned products. Butter was salted, 93 score, extra fancy creamery grade. The water supply, sampled at the kitchen taps, was cultured and found to be free of coliform organisms. Swab samples of the entire inner surface of the cellophane bags used in packaging were cultured for molds, and for aerobic, anaerobic and thermophilic bacteria.

Although mold spores were found in these cultures, tests for the presence of bacteria proved entirely negative in all cellophane bags tested.

Bacterial counts of the air in the packaging room showed a value of only 6 to 13 colonies per plate. These tests, made throughout the packaging operations, were obtained by exposing nutrient agar plates to the atmosphere for a period of 5 minutes.

Routine sanitary precautions were observed in the care of kitchen equipment. All stainless steel table tops used in boning and packaging were thoroughly washed with soap and hot water and were then sponged with a disinfecting solution. The ladles, knives, pans, trays and other utensils used in the preparation of the finished product were steam-sterilized. Large vessels, such as the jacketed kettles and the refrigerating sauce vat, were pretreated with boiling water for 15 minutes. Swab samples of the cleansed surfaces of food equipment were cultured for aerobic organisms and coliform bacteria. These tests showed no coliform organisms and very low counts for aerobic bacteria.

Laboratory Methods

Selection of Samples for Analysis. From the production run of 200 coded cartons of chicken a la king (cold pack) and 200 coded cartons of chicken a la king (hot pack), each twentieth package was removed before freezing for microbiological analysis in a Quartermaster mobile laboratory set up at the plant. The remaining cartons of both hot and cold pack runs were frozen at the plant, and after 36 hours of holding at 0° F. (—18° C.) a series of 10 representative* cartons was similarly analyzed in the mobile laboratory.

The 360 cartons which had not yet been analyzed (180 cold pack and 180 hot pack) were thereupon shipped under dry ice refrigeration at temperatures lower than 0° F. (—18° C.) to the Quartermaster Food and Container Institute for further storage and analysis. Upon arrival at the Institute, 5 representative cartons from each of the hot and cold packs were examined for microbiological population. Another series of 4 representative cartons from each pack was examined organoleptically. The remaining 340 cartons were immediately placed in 0° F. (—18° C.) storage rooms where they were held until withdrawn for subsequent analysis. Microbiological analysis was made on the contents of five cartons from each pack at intervals of approximately 30 days. Four cartons were withdrawn at the same intervals and submitted to organoleptic examination.

Microbiological Evaluation

Preparation of Samples for Culturing. Cartons were removed from 0° F. (—18° C.) storage to a 40° F. (4° C.) room equipped with a trip balance and a supply of prechilled, sterile, wide mouth, glass-stoppered sample bottles. All sampling was done aseptically with sterile cork borers. From several areas of the carton samples of the frozen product were obtained, an effort being made to secure a composite sample of meat and sauce.† Fifty-gram portions were weighed directly into sample bottles. Each sample was transferred to a sterile aluminum Waring Blendor jar and blended with 450 ml. of sterile 0.1 percent solution of sodium taurocholate. By this procedure a 1:10 dilution was obtained. From this suspension, subequent decimal dilutions were prepared.

Determination of Total Viable Organisms. Standard plate counts were made on Bacto tryptone glucose extract agar after 48 hours incubation at 98° F. (37° C.). Duplicate plates were prepared at each level of dilution using 1 ml. of inoculum per plate. Results of plate counts are expressed as the average for 5 cartons, the value for each carton consisting of the average counts from at least 4 plates.

Culture of Coliform Bacteria, Enteric Pathogens, and Anaerobic Organisms. Coliform organisms were cultured in Brilliant Green Bile 2 percent Broth. Enteric pathogens were sought in Selenite Broth cultures. Tests for anaerobic organisms were made in Liver Broth sealed with plain 2 percent agar. Portions of the 1:10 dilutions were used as inocula for each of the above examinations.

The pH measurements were performed on the 1:10 dilutions using an electronic pH meter.

Organoleptic Evaluation

Acceptability was determined by a rating scale technique using a 10-point scale. On this scale, points 6-10 represented degrees of increasing acceptability, and points 1-5, degrees of non-acceptability varying from definite rejection to bare rejection. The observers were a panel of from 24 to 35 persons randomly selected at each test period from among the personnel of the QMF&CI.‡

The packages of chicken a la king were removed from storage at 0° F. immediately before serving. The product was thawed and brought to a temperature of 180° F. (82° C.) over hot water in approximately 35 minutes. Coded samples, 0.5 ounce in size, were presented to the observer in small dishes of a uniform white color. The hot and cold pack samples were always paired on presentation. At the beginning of the experiment the food was tested both as served plain and as served on toast. Later, since ratings were found to correspond closely, the use of toast was discontinued. The results are reported for the first method only.

RESULTS

Survival of Bacteria in Precooked Frozen Chicken a la King at 0° F. (—18° C.)

Standard plate counts were made at monthly intervals using the sampling and counting procedures described above. The data obtained are presented in Table 2 to illustrate the effect of storage at 0° F. (—18° C.) on the pH and numbers of viable organisms in hot and cold packed product during 1 year's storage.

Since less than one coliform organism per gram and no enteric pathogens were recovered from samples taken either before or after freezing, these analyses were discontinued after the first month's storage. Culturing of anaerobic organisms was continued throughout the storage period; however, all tests were negative.

It will be noted that the bacterial count of the hot-filled product is markedly lower than the cold-filled product prior to freezing. Inspection of the data shows that the process of hot filling followed by quick-freezing and 0° F. (—18° C.) storage for 2 months results in virtually a sterile product which is stable and substantially unchanged throughout one year of storage at 0° F. Although the cold-filled product showed a count of 22,000 per gram before freezing, over 60 percent of the bacteria were destroyed in the product 18 hours after subjection to the freezing process. Approximately one month later the bacterial population had been reduced to 14-15 percent of the initial load and thereafter little or no change occurred in the count during the remainder of the year at 0° F. storage. No significant changes in pH were encountered in this study.

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* The term representative is used to mean that cartons were selected by code in accordance with the numerical order in which they were packaged. Thus, representive sampling insured that cartons from the beginning to the end of each run were selected as samples for each analysis.

† The chicken a la king formula consisted of approximately 20 percent chicken meat and 80 percent white sauce. Preliminary experiments conducted on isolated portions of the product showed that roughly 70 percent of the total number of viable bacteria were found in the meat, 30 percent in the sauce. Therefore, it became evident that the proportion of chicken to sauce in the assayed sample would directly influence the total number of bacteria found. Care was accordingly taken to obtain samples which were reasonably similar in composition to the product as a whole.

‡ All observers had previously participated in food acceptance tests and were familiar with the rating scale, but none had had any particular training in judging chicken a la king. Therefore, they should be considered as a consumer preference group.

TABLE 2

Acceptability Rating and Survival of Bacteria in Precooked Frozen Chicken a la King Stored at 0° F. for One Year

Storage Time at 0° F., Days	Hot fill			Cold fill		
	Plate Count Per Gram, Average	pH	Acceptability rating	Plate Count Per Gram, Average	pH	Acceptability rating
0 (prior to freezing)	39	6.1		22,000	6.1	
1.5	35	6.2		8,700	6.2	
4	34	6.1	8.5	5,900	6.1	8.7
36	17	6.4	9.1	3,200	6.3	8.6
77	3	6.2	8.7	3,800	6.2	8.6
97	2	6.2	8.1	3,500	6.3	8.3
134	2	6.3	8.6	2,000	6.3	8.7
160	4	6.3	8.3	2,600	6.3	8.4
197	1	6.3	8.6	4,700	6.3	8.5
229	1	6.4	8.3	4,800	6.3	8.5
257	4	6.2	8.2	3,500	6.3	8.3
290	5	6.3	8.6	3,800	6.4	8.3
313	1	6.3	8.2	3,400	6.4	8.0
340	5	6.3	8.2	2,400	6.2	8.0
376	3	6.3	8.5	4,800	6.3	8.7

Prior to any storage, an initial organoleptic test, in which 161 observers participated, indicated a high level of acceptability for the product. The mean rating on the 10-point scale was 8.6, and the modal rating was 9.0. Only 2 observers rated the product as low as 5.0. A rating of 8.6 on this scale indicates acceptability for the product comparable to that of such highly preferred foods as ice cream, beef steak, and strawberries.

Acceptability tests were run each time when samples were removed from 0° F. (—18° C.) storage. Since the results were completely uniform, they are not presented in detail here. Mean ratings, derived from the responses of from 24 to 35 observers, varied only within the small range of from 8.0 to 9.1. No rating was significantly different from the initial 8.6 rating. Analysis of the observers' comments showed that they noted a difference in appearance and consistency between the hot and cold pack samples which appeared equally as often at all storage periods. The hot pack samples occasioned a significant number of criticisms for shredded and broken pieces of chicken and for thick or "pasty" sauce. It is evident that the difference had but little effect on rating by the absolute judgment technique used here. It is possible, however, that in a choice situation the cold pack would be selected a good deal more frequently than the hot pack.

The Bacterial Flora of Precooked Frozen Chicken a la King

After 10 months' storage at 0° F. (—18° C.), the number of surviving organisms in precooked frozen chicken a la king appeared to have levelled off. An examination of 5 cartons of each pack was made at that time to obtain a cross section of the bacterial flora. From each package one typical TGE plate, previously used for the bacterial count, was selected. From each selected plate, attempts were made to isolate every colony. Over 90 percent of the colonies were successfully isolated and purified by replating several times prior to identification and classification. Morphological and physiological characteristics of the isolates were determined according to Bergey's "Manual of Determinative Bacteriology" (5th Edition).

All of the surviving organisms isolated and identified from the frozen precooked chicken a la king (10 months old) were members of the family *Micrococcaceae*. These included 21 cultures from the hot-pack and 405 cultures from the cold-filled product. The species which were identified are shown in Table 3.

TABLE 3

Microflora of Precooked Frozen Chicken a la King, Isolated After 10 Months' Storage at 0° F.[b]

Genus	Species		
Micrococcus	*candicans*	*flavus*	*saccatus**
	caseolyticus	*freudenreichii*	*sensibilis*
	cereus	*luteus*	*subcitreus**
	chersonesia	*mucofaciens*	*subflavescens*
	conglomeratus	*nitrificans*	*subflavus**
	catonii	*percitreus*	*varians*
	epidermidis	*perflavus**	*viscosus*
Staphylococcus	*albus,** *aureus, citreus,** *muscae,** *pharyngis*		
Sarcina	*citrea, flava, lactea,** *ventriculi**		
Gaffkya	*tardissimi,** *verneti**		

[b] The * refers to organisms found in hot-filled product. The organisms were capable of surviving the pre-fill heat treatment.

The most frequently occurring genus isolated (51 percent) from the cold pack was *Micrococcus;* included were 21 species of this genus. The genus *Staphylococcus* was represented by 5 species (24 percent). Four species of Sarcina (17 percent) and two of Gaffkya (8 percent) were isolated.

Effect of Fluctuating Temperature of Storage on Precooked Frozen Chicken a la King

In order to simulate temperature conditions which might normally occur during long transit of frozen foods in refrigerator cars or cargo ships, a test was conducted to collect data on the changes in the bacterial population and the acceptability of the product in relation to the temperature fluctuations within the range, 20° to 30° F. (—6.7° to —1° C.), specified above.

Five cartons each, of the hot- and cold-packed chicken a la king were withdrawn from the 0° F. (—18° C.) room after 36 days' storage and placed in a thermostatically controlled variable temperature chamber. The controls were adjusted to cycle the temperature from 20° F. (—6.7° C.) to 30° F. (—1° C.) and then back to 20° F., the cycle requiring a five day period to complete. After three cycles had been concluded, the cartons were returned to 0° F. (—18° C.) storage for five additional days.

Initial bacterial counts were made on separate sets of 5 cartons withdrawn from the 0° F. (—18° C.) room simultaneously with those packages placed in the variable temperature cabinet. At the completion of the 15-day cycling period, and again after five days at 0° F., bacterial counts were made on samples taken from the temperature-cycled packages.

Organoleptic tests conducted in this study, and in those described below, showed that none of the various temperature conditions employed had any appreciable effect on the flavor or acceptability of the products.

From the data shown in Table 4 it may be seen that no significant population changes occurred in the product contained in hot-filled packages either during the temperature fluctuation period or as a result of the refreezing treatment. The cold-filled product showed a significant decrease in count after the cycling interval but no further change in count upon refreezing.

TABLE 4

Survival of Bacteria and Acceptability Rating for Precooked Frozen Chicken a la King Under Conditions of Fluctuating Storage Temperatures

Time of Sampling	Hot fill		Cold fill	
	Plate count, average, per gram	Acceptability	Plate count, average, per gram	Acceptability
Initial (0° F.)	17	8.7	3,200	8.6
After 15 days at cycling temperatures (20° F.-30° F.)	6	8.2	1,700	8.6
Final, after 5 days of refreezing at 0° F.	10	8.2	1,800	8.7

Effect of Thawing and Refreezing on Precooked Frozen Chicken a la King

To learn the effects of thawing and refreezing of frozen foods in transit to a restaurant kitchen, a garrison kitchen, or to a military force in the field, an experiment designed to measure changes in bacterial population and food acceptance occurring under such conditions was initiated. As a refrigerator temperature typical of thawing, 40° F. (4° C.) was selected. For the subsequent refreezing temperature 0° F. (—18° C.) was chosen. The experiment was conducted as follows: Cartons from each type of pack were withdrawn from 0° F. storage after 4 months and were placed in a 40° F. refrigerator. After 72 hours of holding at 40° F., the packages were returned to the 0° F. storage for 24 hours of refreezing. Samples, taken at each stage, were examined bacteriologically and organoleptically. The microbial population data are presented in Table 5.

TABLE 5

Effect of Thawing and Refreezing on the Number of Viable Organisms In Precooked Frozen Chicken a la King and Upon Acceptability

Time of Sampling	Hot fill		Cold fill	
	Plate count, average, per gram	Acceptability	Plate count, average, per gram	Acceptability
Initial (0° F.)	3	8.6	6,800	8.7
After thawing for 72 hours	3		7,600	
Final, after refreezing at 0° F., 24 hours	2	8.3	4,000	8.7

Effect of Thawing Precooked Frozen Chicken a la King at 70° F. for 24 Hours and Refreezing

In this experiment conditions which might occur in the event refrigeration equipment failed to operate were simulated. When mechanical breakdowns happen, they may remain unrepaired or undiscovered for a sufficient length of time to permit frozen foods to thaw completely. Cartons of precooked frozen chicken a la king, previously held at 0° F. (—18° C.) for 8 months, were allowed to stand at 70° F. (21° C.) for 24 hours, and were then returned to 0° F. storage in order to refreeze the products. Samples were taken for bacteriological examination before and after thawing and 24 hours after refreezing.

Bacterial counts shown in Table 6 indicate a marked increase in the case of the cold fill cartons which were held at 70° F. (21° C.) for 24 hours. The refreezing treatment reduced their count only slightly in 24 hours. No significant change in bacterial count occurred in the hot filled product either after thawing or after refreezing.

TABLE 6

Acceptability and Growth of Bacteria in Precooked Frozen Chicken a la King Upon Thawing at 70° F. and 24 Hours of Refreezing

Time of Sampling	Hot fill		Cold fill	
	Plate count, average, per gram	Acceptability	Plate count, average, per gram	Acceptability
Initial (0° F.)	6	8.3	2,700	8.0
After thawing (70° F.)	8	.....	13,000	.....
Refreezing (0° F. for 24 hours)	7	8.6	10,500	8.2

DISCUSSION

The various experiments demonstrate that a good product can be made by exercising sanitary measures somewhat more strict than those currently in use within the frozen food industry. From this investigation it is apparent that low counts can be expected if high quality raw materials are used, if plant sanitation is scrupulously enforced, and if storage conditions are adequately controlled. It should be emphasized that without materially adding to the cost, the product used in this experiment was adequately processed and was thereafter carefully handled to preclude recontamination. Worthy of mention also is the fact that the extra amount of heating given the hot pack accounted for further destruction of bacteria. In fact, the product was virtually sterile. The higher count observed in the cold-filled product would appear to indicate either that the organisms multiplied during the holding period at low temperatures or that recontamination took place prior to filling. In both types of pack, however, the count was significantly below that reported by other workers using similar commercial products obtained from food retail stores *(1, 2, 3)*. From this investigation it is also apparent that precooked chicken a la king stored under a variety of adverse temperature conditions will maintain its keeping qualities if the initial bacterial count is low.

SUMMARY

Bacteriological study of precooked frozen chicken a la king demonstrated that a final product of high acceptability and very low bacterial count can be manufactured when good sanitary practices are observed. Comparison of two methods of packaging showed that a substantially sterile product resulted from "hot filling" at 189° F. (87° C.)-212° F. (100° C.), while standard plate counts of 4,000-6,000 per gram were obtained from "cold filling" at 55° F. (13° C.) or below.

Both types of pack stored for one year at 0° F. (—18° C.), showed little or no decrease in bacterial count after the second month of storage. High acceptability ratings were maintained throughout the storage at 0° F. The surviving microflora after 10 months' storage at 0° F. were identified as members of the genera *Micrococcus, Staphylococcus, Sarcina* and *Gaffkya*.

A storage test at fluctuating temperatures between 20° F. (—6.7° C.) and 30° F. (—1° C.) for 15 days, simulating transportation conditions, indicated a significant decrease in bacterial population which was not further reduced by subsequent refreezing at 0° F. (—18° C.). Thawing at 40° F. (4.4° C.) for 3 days produced only a slight increase in bacterial numbers;

however, a net decrease resulted from subsequent refreezing at 0° F. (—18° C.).

When the frozen product was allowed to thaw completely at 70° F. (21° C.) for one day, the bacterial population increased markedly; it was not significantly decreased by subsequent refreezing at 0° F. (—18° C.).

Acknowledgment

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Effect of Enzyme Inactivation on Quality Retention in Frozen Brussels Sprouts

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Data are presented which indicate that blanching to catalase inactivation is not sufficient for quality retention in frozen Brussels sprouts. Peroxidase activity serves as a satisfactory index for adequacy of blanch for this commodity. Samples containing active peroxidase (catalase inactivated) were compared with peroxidase-negative samples after storage at —23° C. (—10° F.) for 10 months. The former showed the following changes: (a) marked development of off-flavor, (b) decrease in natural flavor, and (c) development of pink coloration at centers. The pink centers appear within a short time after processing.

The present data are part of a general study at this Laboratory, concerned with relation of degree of enzyme inactivation to quality retention in frozen vegetables.

It is well established that certain enzymes or enzyme systems must be inactivated or partially inactivated if vegetables are to retain quality during freezing storage. Such inactivation is accomplished by blanching (scalding). Since the enzyme systems directly responsible for quality deterioration in raw or underblanched vegetables during freezing storage are as yet unknown, certain enzymes, such as peroxidase and catalase, have been used as test substances to determine adequacy of blanching in vegetables to be preserved by freezing.

Joslyn *(2)* has stated that, in general, vegetables blanched sufficiently to inactivate catalase and peroxidase will not develop off-flavors in freezing storage. Peroxidase, being more heat-stable, would seem to be the more desirable as an index of adequacy. This has been borne out for peas and spinach by the work of Arighi, Joslyn, and Marsh *(1)*, who found that catalase was quantitatively inactivated at a much faster rate than the enzymes concerned in the production of off-flavor. Unpublished results obtained in this laboratory have indicated that peas blanched to a degree sufficient to inactivate catalase (peroxidase only partially inactivated) were inferior in flavor after two months of storage at —23° C. (—10° F.) to peas in which both enzymes had been inactivated.

It is conceivable, however, that the relative stability of the two enzymes to heat may be different in other commodities and that the same enzyme may not be the best test substance for all products. Indeed, unpublished data obtained in this Laboratory indicate that in lima beans, catalase, or a system with similar activity, is somewhat more heat stable than peroxidase.

Quantitative data directly comparing heat stabilities of the two test enzymes are lacking for most commodities commonly frozen. The purpose of the present work is to make such a comparison and to determine the effect of varying degrees of blanching on the quality of frozen Brussels sprouts.

PROCEDURES

The raw material used was obtained January 15, 1949, from the Half Moon Bay area in California which is located about 25 miles south of San Francisco. When received, about three hours after picking, the sprouts were still quite cool. Although the temperature was not taken, it can be safely estimated as being under 7° C. (45° F.) because of the unusually low prevailing temperature.

The crates were top-iced and transported quickly to the laboratory, where they were placed in storage at 0.6° C. (33° F.) over night. On the following morning, the sprouts were trimmed and adjusted to constant temperature by immersion for a pre-determined time in a large vat of water, constantly agitated by several streams of air. After temperature adjustment, they were placed on stainless-steel mesh trays at a loading rate of 1.33 pounds per square foot and blanched in a draper-type belt steam blancher for varying periods at 100° C. (212° F.). The blanched material was cooled by a fog spray drawn through the trays by means of a suction fan. The trays were drained and the sprouts were packaged in 450 MSAT cellophane bags, placed on trays, frozen in an air-blast at —23° C. (—10° F.) and then stored at this temperature.

In this series, samples were blanched 2, 3, 4, 5, 6, 8, and 10 minutes. Peroxidase was determined both by the semi-quantitative and quantitative tests as described by Masure and Campbell *(4, 5)*. Catalase was likewise determined both qualitatively and quantitatively. The qualitative test was suggested by H. J. Morris of this Laboratory. Several halves of the larger and firmer sprouts from each blanch lot were chopped very finely and well mixed. A 5 gram sample of this material was placed in a large test tube and 20 ml. of distilled water were added. Care was taken to exclude air bubbles. Two drops of 30 percent hydrogen peroxide were then added and the contents were mixed with as little agitation as possible. The continuous evolution of bubbles of gas from the surface of the sprout particles was taken as evidence of catalase in the sample under consideration. For the quantitative estimation, the method of Line-

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weaver and Morris *(3)* was used. The results of the enzyme assays at the time the samples were processed and at the time of appraisal are given in Table 1.

TABLE 1

Enzyme Assays Before and After Frozen Storage of Brussels Sprouts

Blanching Time at 100° C. (212° F.), Min.	Peroxidase, D/M Units		Catalase, K_{T0}	
	After blanching	After 10 months' storage	After blanching	After 10 months' storage
0 (control)	1770 (+)[b]	1950	0.148 (+)[b]	0.033
2	600 (+)	460	0.019 (+)	0.0
3	210 (+)	150	0.003 (±)	0.0
4	..... (−)	0.7	0.0 (−)	0.0
5	0	0.0	0.0	0.0

[b] Results of semi-quantitative adequacy of blanch test *(4)* which were run at the time of processing only; the sign + indicates inadequate blanch, the sign — adequate blanch.

Examination of the data indicates that, under the conditions of the experiment, the heat stability of catalase is less than that of peroxidase. Likewise, it will be noted that catalase activity in these samples disappeared as they were held in freezing storage. Thus, at the end of 10 months at —23° C. (—10° F.), none of the blanched samples was found to contain active catalase, although one sample contained about 13 percent residual active enzyme immediately after processing.

Appraisal of Samples. Samples were prepared for appraisal by steaming sufficiently so that total steaming time (blanching plus preparation for tasting) was 17 minutes. For example, the sample blanched 2 minutes was steamed for 15 minutes while that blanched 10 minutes was steamed for 7 minutes, etc. Thus all samples were cooked to approximately the same degree.

Appraisal was carried out after 10 months of storage at —23° C. (—10° F.) by a panel of 8 to 10 judges. Each sample presented was made up of a quarter sprout from each of 4 heads from the same blanching lot. The judges were asked to score natural flavor, off-flavor, and color of the centers. Green to yellow inner leaves were considered normal. Any pinkish cast in the centers was considered abnormal and resulted in lower grades. Scoring was done on a numerical scale of 1 to 7, the top score indicating highest quality.

Seven samples were judged. Since it has been felt that such a large number of samples cannot be judged satisfactorily at one sitting, the samples were divided into two groups, five in one and four in the other. Each group contained two samples in common, those blanched 5 and 8 minutes. Each group of samples was scored four times. Average scores for all judges on each day were used in the analysis of variance. The data are shown in Table 2.

TABLE 2

Catalase and Peroxidase Activities and Quality of Frozen Brussels Sprouts

Appraisal After 10 Months' Storage at —23° C. (—10° F.).

Blanching Time, Min.	Enzyme Content of Samples [c]		Averaged Judges' Scores [d]		
	Peroxidase D/M Units	Catalase K_{T0}	Natural Flavor	Off-Flavor	Color of Centers
0	1950	0.033	1.3	1.3	1.7
2	460	0	2.4	2.8	2.6
3	0	0	5.8	6.6	6.6
8	0	0	5.8	6.5	6.1
10	0	0	5.4	6.1	6.0
Least Difference Between Scores for P = 0.01 [e]			0.9	0.7	0.7
3	150	0	3.7	3.9	3.6
4	0.7	0	6.0	6.5	6.3
5	0	0	5.2	6.2	6.0
8	0	0	5.7	6.6	6.2
Least Difference Between Scores for P = 0.01			0.7	0.6	0.9

[c] Assay at time of appraisal of samples.

[d] A score of 7 indicates good natural flavor, no off-flavor, and natural greenish to yellow colored centers.

[e] If differences between averaged judges' scores are as large as, or larger than, the value listed, there is only one chance in a hundred that the results obtained are in error. Since this is a much more stringent statistical criterion than is usually used in biometrics, the reliability of differences is thereby increased.

DISCUSSION AND CONCLUSIONS

The results of the appraisal of both groups of samples indicate clearly that samples in which peroxidase had been inactivated maintained quality over the ten-month period. On the other hand, those which contained residual peroxidase had a marked off-flavor, had decreased in natural flavor, and had developed an abnormal pink coloration at the centers. In view of these findings it is evident that semi-quantitative and quantitative tests for peroxidase, as described by Masure and Campbell *(4, 5)*, serve as a satisfactory index for adequacy of blanching for frozen Brussels sprouts.

Catalase is not suitable for this purpose, as evidenced by data for the sample blanched 3 minutes. This particular sample was graded down very significantly by the panel in all factors considered. Yet at the time of processing it showed only a trace of catalase, while after 10 months' storage no catalase could be detected.

The pinkish discoloration of most of the under-blanched sprouts is worthy of further discussion. The extent to which it occurred was, as might be expected, dependent on the time of blanching. As time was increased and more time allowed for penetration of heat into the center of the sprouts, the colored area became smaller and concentrated more toward the center of pieces.

The samples used were not examined for pink centers at the time of processing; however, in a subsequent series, the discoloration was found to have developed in under-blanched frozen sprouts by the day after processing. Hence, the development seems almost immediate. This latter series is now being studied to determine the effect of time of storage on off-flavor development. It suffices to say here that in this series off-flavor was present in samples with pink centers in less than one month of storage at —23° C. (—10° F.).

Thus the appearance of pink centers in frozen Brussels sprouts seems to be a definite indication of under-blanching. The close correlation between development of off-flavor and pink discoloration would indicate that any frozen samples that exhibit this color abnormality are likely to be inferior in quality.

The data presented in the tables were obtained with a single lot of raw material. However, subsequent work which is still in progress at this Laboratory substantiate the results and conclusions.

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Influence of Variations in Technique and Environment on the Determination of Consistency of Canned Sweet Corn [a, b]

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(Manuscript received October 16, 1950)

Factors affecting the use of the Adams consistometer for cream-style corn have been investigated. Temperature of the corn, degree of consistency, time of spreading, angle and surface of the truncated cone all had highly significant effects. Rate of lifting and methods of washing were without effect. This study illustrates the "Analysis of Variance" method of approaching a laboratory problem, where several factors can be studied at the same time.

Publication by the Federal Security Agency of Definitions and Standards of Identity, Quality, and Fill of Container for Canned Corn *(1)* includes recommendations for the determination of consistency as a factor of quality.

The description of the apparatus to be used for these determinations agrees closely with that of the Adams consistometer. This equipment was designed and first described by Adams and Birdsall *(3)*. The essential parts are a truncated conical container and a flat circular plate marked with concentric circles one fourth inch apart and with four equally spaced quadrant lines. In operation, the hollow truncated cone is placed at the center of the plate and filled with the product being tested. The cone is removed and the radial spread of the product is measured at each quadrant line. Tests made with this apparatus indicated good agreement between objective and subjective determinations of consistency. A comparison of readings by two operators *(3)*, provided some proof that error from this source should be small.

The Adams consistometer has been used to a limited extent in the corn canning industry. Recently the National Preservers Association has proposed the use of a similar apparatus for the determination of the consistency of preserves *(2)*. With the promulgation of standards for canned corn by the Food and Drug Administration it is likely that the Adams consistometer (or similar devices) will come into increasing use both by canners and by regulatory agencies. As a result, it will be desirable to have available information concerning the factors which affect its performance.

Previous workers *(6, 8)* have considered the effects of temperature, time, maturity, starch, sugar and moisture on the apparent consistency of canned corn. In the present work, a Stormer viscosimeter was used to determine consistency and very little attention was given to the effects of operational variables on the use of the instrument. The present study was made in an effort to define more clearly the effects of some of the variables believed to have a bearing on the operation of the Adams apparatus. The seven variables considered most important in the operation of this consistometer were (1) rate of lifting the truncated cone, (2) temperature of the corn, (3) consistency of the corn, (4) time allowed for spreading, (5) methods of cleaning the apparatus, (6) angle of the cone, and (7) surface of the cone exposed to the corn being tested.

Each of the seven variables was applied at three levels (Table 1) in an effort to test the effect of each variable within the limits selected for the tests.

TABLE 1

Levels of Seven Variables Included in Fractionally Replicated Design for a Study of the Consistency of Canned Sweet Corn

Code	Variable	Units	Levels applied		
			0	1	2
A	Rate of lifting	Seconds	0.34	1.0	3.0
B	Temperature of corn	Degrees F.	40	70	100
C	Degrees of consistency	Arbitrary	Thin	Med.	Thick
D	Time of spreading	Seconds	10	20	30
E	Methods of cleaning	.....	Cold water	Hot water	Hot water plus detergent
F	Angle of cone [c]	Degrees and minutes	2° 43″	5° 43″	8° 43″
G	Surface of cone [c]	Sq. cm.	200	250	300

[c] Volume of all cones was 385 ml.

The importance of rate of lifting derives from the fact that Adams consistometers are, in some cases, provided with a strong spring lift and in others the lifting is done by hand. No account has been taken of the difference between spring and hand lifts in this design but the three levels here used are taken to approximate a reasonable range of hand lifts.

Temperature is known to have an effect on consistency and was included to discover the extent of interaction between these two variables. The degree of consistency was included as a variable to broaden the limits of the test and allow application of the results to cream style corn of any thickness.

Since no evidence has been displayed to indicate that 30 seconds is a unique observation time, 10, 20, and 30 seconds were used in the observation of time of spreading to investigate the effects of these deviations on the operation of the apparatus.

The method of cleaning was introduced because this may have an effect on the physical condition of the surface over which the corn spreads and may therefore influence the rate and extent of flow.

Angle and surface of the cone were investigated to discover any trend toward a combination of physical attributes of the apparatus which might allow easier, quicker, or more accurate consistency determinations.

[a] Work on this project was made possible through a grant from the Iowa-Nebraska Canners Association.

[b] Journal Paper No. J-1848 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 1052 and 890.

EXPERIMENTAL PROCEDURE

Fifteen lots of canned corn were tested under similar conditions using the Adams consistometer to determine the consistency. From these lots, three were chosen to represent thin, medium and thick consistency in such fashion that no overlapping occurred, and that the variation within each lot was small relative to the differences among the three levels of consistency.

The rate of lifting of the truncated cones was actuated by a gear-head motor with a shaft speed of 30 r.p.m. A 3-step pulley and a spring-loaded clutch assembly were mounted on the motor shaft. The rotary motion of the pulley was used to lift the cone by connecting the two with a cord (Figure 1). The resulting rates of lifting were 0.34, 1.0 and 3.0 seconds required to lift the cones 5 inches from the plate.

FIG. 1. The Adams consistometer equipped with automatic timing and lifting device.

The clutch was used in conjunction with a limit switch wired in series with the motor switch to prevent damage to the apparatus due to coasting after completion of a 5-inch lift and to allow readjustment of the assembly for the next run.

The temperature of the corn used in the tests was maintained within 1° C. (2° F.) of the desired levels by immersion in water baths. Frequent temperature measurements of the baths and the can contents established the low variability of temperatures during holding prior to the test. Each test was made immediately after removal of the sample from the water bath.

The consistometer readings were observed after 30 seconds of spreading had elapsed. Readings at 10, 20, and 30 seconds were also recorded with a motion picture camera mounted above the consistometer. The floodlights and camera were mounted on the ceiling over the consistometer and focused to include all of the circular disk and an electric timer which measured seconds and tenths of a second. At 9, 19, and 29 seconds the camera and lights were operated simultaneously for approximately two seconds at each time to record both the time and the position of the flowing corn (Figure 2). Final measurements for the statistical analysis were made by projecting the film on a screen where accurate estimates of radial spread could be made in each quadrant. The measuring operation was made easier by stamping quarter-inch numbers along the quadrant lines of the plate. These numbers were arranged to indicate diametric inches from the center of the plate. A part of the measurements were made independently by two operators to establish the fact that operator variation was negligible (Table 2). The remaining measurements were made by one operator.

FIG. 2. Film strip showing the appearance of the spreading corn on the Adams consistometer plate.

TABLE 2

Comparison of Two Operators in Determining Consistency on One Day's Run of Canned Sweet Corn. Analysis of Variance.

Source	Degrees of freedom	Sum squares	Mean square	F
Cans	26	1844.08	70.93	
Operators	1	0.80	0.80	1.19 [4]
Error	26	17.45	0.67	
Total	53	1862.33		

[4] Nonsignificant.

The three methods of cleaning were applied with the full realization that many other treatments exist. However, these are methods which might be commonly used in a control laboratory and derive their importance mainly from this fact.

The three characteristics of a truncated cone which might be expected to affect the operation of the Adams consistometer are the angle, surface area and volume of the cone. The constant volume of all the test cones was maintained to conform with that of the standard cone supplied with the apparatus which is of a convenient volume for routine use.

Nine truncated cones of varying angle and surface were manufactured from stainless steel by forming on conical wooden mandrels. These cones were provided with mounting bars similar to those of the standard cone and used to test the influence of angle and surface of the cone on the operation of the consistometer. At each angle three cones were prepared having surfaces of 200, 250 and 300 sq. cm.

Experimental Design

This study involved the determination of the effects singly and in combination of seven factors each at three levels. A single replicate of each of the treatment combinations would require 3^7 or 2,187 individual determinations, because the level of each factor to be used in an individual determination may be chosen in three ways independently of the choice of level for all the other factors. The amount of work involved in such a test was completely prohibitive and furthermore not entirely necessary. The number of treatment combinations which should be tested depends essentially on the magnitude of the interactions between the factors. The concept of interaction is illustrated by artificial data in Table 3.

TABLE 3

Artificial Consistometer Readings Showing Absence and Presence of Interaction Between Temperature of Measurement and Time of Observation

No interaction		
Temperature (° F.)	Time of Observation (seconds)	
	10	30
40	6	7
100	8	9

Interaction		
Temperature (° F.)	Time of Observation (seconds)	
	10	30
40	6	6.5
100	8	9.5

Where no interaction is shown, the effect of changing the time of observation is the same for both temperatures, i.e., the difference between readings taken at the two temperatures is 2 units when the observations are made at 10 seconds and 2 units when they are made at 30 seconds. Where interaction is shown, the change in time of observation depends on the temperature and the difference in readings for the two temperatures is 3 units at 10 seconds and 2 units when the readings are taken at 30 seconds.

If there are no interactions among the seven factors, each factor could be tested independently of the others, say 15 times for each level of each factor. In this way 45 determinations could be used for the estimation of the effect of each factor, and the total would be 45 x 7 or 315 determinations. Such an

investigation would not give any indication of whether there are interactions or not, because when one factor is varied the other six are kept constant. As an alternative, the assumptions may be made that interactions between two factors exist, but additional interactions between three or more factors are negligible. This enables the use of a fractionally replicated design *(4, 7)* in which one-ninth of the 2,187 treatment combinations are tested, using only 243 determinations. This set of 243 treatment combinations was chosen in a way which is based on the mathematical theory of the design of experiments. The 243 treatment combinations were divided into nine groups (designated as Day 1-9) consisting of 27 determinations each of which were tested on separate days. For a general discussion of the value of factorial experiments, the reader is referred to Fisher *(5)*.

RESULTS AND DISCUSSION

The statistical procedure by which the experimental results are evaluated was that of the analysis of variance. The resulting analysis is shown in Table 4, except that

TABLE 4

Effects of Seven Variables on Consistency of Canned Sweet Corn
Analysis of Variance

Source of variation	Degrees of freedom	Sum of squares	Mean equare	F
Block	8	38.98		
Error	136	213.46	1.57	
Treatments	98	7,547.89		
A. Rate of lifting	2	6.33	.....	.....
B. Temperature of corn	2	577.93	288.96	184.05**
C. Degrees of Consistency	2	6,688.31	3,344.16	2,130.04**
D. Time of spreading	2	98.40	49.20	31.34**
E. Methods of cleaning	2	1.05	.....	.....
F. Angle of cone	2	17.28	8.64	5.50**
G. Surface of cone	2	16.79	8.39	5.34**
Two-factor interactions	84	141.80	1.69	1.1
B x C	4	20.23	5.06	3.22*
E x G	4	13.38	3.34	2.13
F x G	4	18.96	4.74	3.02*
Total	242	7,800.33		

* The * denotes significance at the 5 percent level; the sign ** significant at the 1 percent level.

the sums of squares for non-significant two-factor interactions are not presented separately. The existence of effects or interactions is judged by the criterion of statistical significance.

Table 6 indicates that temperature of corn, degree of consistency, time of spreading, angle of cone and surface of cone have highly significant effects on the consistency readings. Interaction between temperature and consistency and between angle and surface of cone were also shown to be significant. It should be noted however that the statistical significance of an effect is in no way related to the practical importance of the same effect. The experiment in fact achieved a very high degree of sensitivity because of the large number of observations. The practical implications of the demonstrated effects will be discussed below.

Verification of the validity of the experimental design was achieved by obtaining an estimate of the error of repeated observations on the same lots of corn. This was found to be 1.46 which is very little different from the error variance of the experiment of 1.57. The similarity of these two error variances demonstrates that high order interactions are trivial and this was the basis of the fractional design. There was some evidence of a higher variance for the readings between cans on the material with thin consistency than on those with thick consistency. It was felt, however, that this could be ignored in applying the analysis of variance procedure.

The practical importance of the effects of the factors tested may be observed in Table 5 in which the mean readings of each of the factors is given for each level. For example the mean reading with 10 seconds allowed for spreading was 7.2, with 20 seconds 7.4, and with 30 seconds 7.6.

TABLE 5

Estimates of Effects of the Seven Variables Tested on Determinations Made With the Adams Consistometer

Rate of lifting	level (sec.)	0.34	1.0	3.0
	mean reading (inches)	7.4	7.5	7.4
Temperature of corn	level (° F.)	40	70	100
	mean reading (inches)	7.0	7.3	7.9
Consistency	level	thin	medium	thick
	mean reading (inches)	9.2	7.0	6.1
Time of spreading	level (sec.)	10	20	30
	mean reading (inches)	7.2	7.4	7.6
Methods of cleaning	level	cold water	hot water	hot water plus detergent
	mean reading (inches)	7.4	7.4	7.4
Angle of cone	level (deg.)	2° 43"	5° 43"	8° 43"
	mean reading (inches)	7.3	7.4	7.5
Surface of cone	level (sq. cm.)	200	250	300
	mean reading (inches)	7.5	7.4	7.3

There was a consistent increase in readings with increase in time of spreading, so that in any routine use of the apparatus the time of spreading should be specified. For example, the use of 10 seconds rather than 30 seconds will result in a lowering of the reading by approximately 0.4 inch. Variation of approximately 0.2 inch due to rate of lifting, method of cleaning, angle of cone and surface of cone over the ranges investigated indicates that changes in these factors probably will produce little variation in the final readings.

The effect of the temperature of the corn sample was very pronounced, in accordance with general knowledge, and account of this variable should be taken when one set of observations is compared with another. If readings at 70° F. (21° C.) are designated as the standard of comparison, readings taken at 40° F. (4° C.) should have 0.3 inch added, while readings taken at 100° F. (37° C.) should have 0.6 inch substracted in order to standardize them.

The estimate of interaction of the factors of temperature and consistency is shown in Table 6. Examination of the means does not indicate a strong trend and the interaction, while statistically significant, is of little importance practically. The interaction arises because

TABLE 6

Interaction of Temperature and Consistency in the Determination of Consistency in Canned Sweet Corn

Consistency	Temperature (F.)			Mean	Differences in readings between pairs of observation temperatures (° F.)		
	40°	70°	100°		70-40	100-70	100-40
Thin	8.7	9.2	9.7	9.2	0.5	0.5	1.0
Medium	6.6	6.9	7.4	7.0	0.3	0.5	0.8
Thick	5.7	5.8	6.7	6.1	0.1	0.9	1.0
Mean	7.0	7.3	7.9				

a change of temperature from 40° to 70° F. has little effect on thick corn and a comparatively large effect on thin corn.

SUMMARY

Use has been made of a fractionally replicated design to test the effects of seven variables on the operation of the Adams consistometer.

Temperature of the corn, degree of consistency, time of spreading, angle and surface of the truncated cone, all had highly significant effects. Rate of lifting and the methods of washing employed were without effect.

Significant first order interactions were noted between temperature and consistency of the corn and between angle and surface of the cones. The interaction between methods of cleaning and surface of the truncated cones approached significance at the five percent level.

Comparisons among observations of consistency determined through use of the Adams consistometer should be made only after correction for differences in times of spreading and for the temperatures of the samples.

The angle and surface of the truncated cones, rate of lifting and method of washing appear to be of very little practical importance in the operation of the instrument.

The design used in the investigation provided a high degree of sensitivity for the determination of statistical significance. Considered from a practical point of view, however, only the temperature of the corn sample and the time of spreading produced effects of a magnitude likely to alter appreciably the estimated consistency of a sample.

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Manufacture of Concentrated Milk and Honey Products[a]

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Concentrated milk and honey products of good storage stability were prepared including honey-sweetened condensed milks, evaporated milk fortified with honey, and dried honey-skim milk with 40 percent honey solids and 60 percent skim milk solids. Methods of manufacture and properties of the products are described.

INTRODUCTION

Milk and honey blend readily to form mixtures that appeal in flavor and palatability to many people. Mixtures of milk and honey are high in energy value and there is evidence that the normal honey acids may exert a favorable effect on the digestibility of the milk proteins *(5, 7, 9)*.

Schlutz and Knott *(9)* found honey to be of unusual value when used as the carbohydrate component of infant diets. Honey was among the best of the carbohydrates with respect to the speed with which the sugars were assimilated, and it was the best carbohydrate with respect to the length of time a moderately high level of blood sugar was maintained. Also, the inclusion of honey in the diet was found "to have a definite beneficial influence upon the retention of calcium by young infants" *(4)*.

Because of the unique food value of both milk and honey, and also because both products are produced in surplus quantities at times, the cooperative experiments reported herein were undertaken to devise methods of preparing mixtures of milk and honey which would be suitable for use in the manufacture of other foods. Earlier studies *(1)* by the Bureau of Dairy Industry had shown the possibility of combining milk and honey in a number of products. Emphasis was placed on the preparation of concentrated milk and honey products, since such products would provide a means of introducing the flavor and nutritive value of these ingredients into other foods with a minimum of processing losses.

As a result of these cooperative experiments, methods have been devised for preparing three types of concentrated products from milk and honey: (1) honey-

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sweetened condensed milk, (2) honey-evaporated milk, and (3) dried honey and milk mixtures. The manufacturing work was carried out on a pilot plant scale using the experimental equipment available in the Dairy Products Research Laboratory of the Bureau of Dairy Industry.

The sweetened condensed and evaporated mixtures, which are made with whole milk, are considered especially useful in infant diets and in other special diets. The dried mixtures, which are made with skim milk, should be useful in food manufacture, especially to commercial and retail bakers, as a component of prepared dry mixes for baking, in fortified modified milk powders and concentrates, and in cocoa, beverage, dessert, and ice-cream mixes. It should also be useful in confectionery.

EXPERIMENTAL METHODS AND RESULTS

Honey-Sweetened Condensed Milk. Comparative batches of sweetened condensed milk were made with sugar and with honey as the preserving agents. Representative results are shown in Table 1. The honey-sweetened milks were high in honey flavor and, when proper manufacturing methods were used, the flavor was quite stable.

Thickening to the point of gelation (about 600 poises) during storage is a common defect in sweetened condensed milk. When the product is prepared from milk that has developed some acidity, the tendency toward thickening is increased. Batches made with normal honey thickened rapidly, but when the acidity of the honey was partially neutralized (batches 2 and 4 of Table 1) the tendency to thicken was greatly retarded.

Neutralization of the honey was done carefully, since over-neutralization was detrimental to the honey flavor. Pure, finely powdered calcium carbonate and tri-sodium phosphate proved to be the best agents for partially neutralizing the active acidity of the honey. The honey was diluted to a 60-percent sirup, an aqueous mixture or solution of the neutralizing agent was added, and the honey was then pasteurized to destroy the enzymes that produce objectionable changes in condensed milk during storage.

Since it is well known that dextrose in sweetened condensed milk promotes thickening, an abnormal increase in the viscosities of the honey-sweetened samples was expected. The difference in the viscosities developed by milks that contain honey and sugar is shown in Figure 1.

Milk subjected to high-temperature short-time forewarming before it is concentrated produces a sweetened condensed milk of lower viscosity than when normal forewarming treatment at a temperature below 200° F. (93° C.) is used *(15)*. In Table 1 and Figure 1, comparison of the batches of milk forewarmed at 180° and 240° F. (82° and 116° C.) shows that the higher temperature retarded thickening in both the control and honey-sweetened samples.

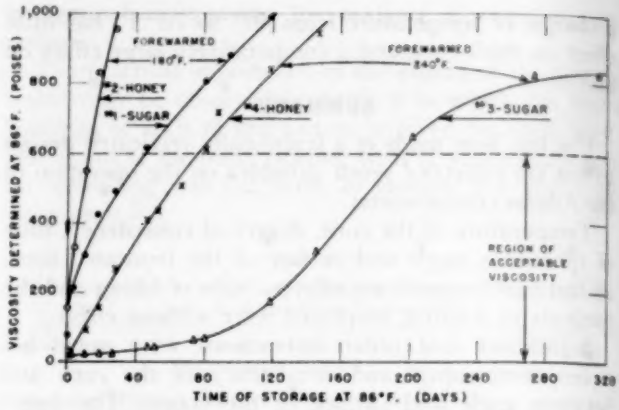

FIG. 1. The effect of forewarming milk to 180° F. (No. 1 and No. 2) and to 240° F. (No. 3 and No. 4) upon the storage viscosity of sweetened condensed milks made with sugar (No. 1 and No. 3) and with honey (No. 2 and No. 4).

Honey-sweetened condensed milk may be manufactured by adding 22½ pounds of honey to 100 pounds of milk. The milk should be forewarmed at 240° F. (116° C.) for 30 seconds and drawn into the vacuum pan. The honey should be partially neutralized to pH 5.8 and pasteurized at 170° F. (77° C.) for 20 minutes, then drawn into the vacuum pan following the milk. After concentration to about 72 percent solids (sugar ratio >60; see footnote *e*, Table 1), the product should be cooled and agitated to crystallize the lactose, using the normal treatment for sweetened condensed milk. Honey-sweetened condensed milk should be packaged in airtight containers to retard mold growth. When it is held below 70° F. (21° C.) it will remain in satisfactory condition for 5 to 6 months. It should be emphasized that the viscosity of sweetened condensed milk increases logarithmically with increases in storage temperature and arithmetically with increases in storage time *(16)*.

Several batches of honey-sweetened condensed whey were manufactured by following a process described by Ramsdell and Webb *(8)* for sugar-sweetened condensed whey. Honey and whey were condensed together to produce a concentrated mixture containing 38.5 percent each of honey and whey solids. The reaction of the mixtures was about pH 5.36. Neutralization of the honey was not necessary. Concentrated honey-whey mixtures showed good storage stability, since they contained no casein. Casein is the milk constituent largely responsible for thickening of sweetened condensed milk. Honey-sweetened condensed whey would be useful in food manufacture where concentrated forms of whey and honey are needed.

Honey-Evaporated Milk. Canned, evaporated milks, modified for infant feeding by inclusion of various carbohydrates, have attained some commercial importance.

The composition and characteristics of some evaporated milks made with various quantities of added honey are shown in Table 2. The quantity of honey added to the milk had a marked effect on the viscosity of the milk after sterilization. Neutralization

TABLE 1

Characteristics of Sweetened Condensed Milks Made With Sugar and with Honey, When the Forewarming Temperature was 180° or 240° F.[a]

Sample No.	Carbohydrate added	Forewarming conditions		Composition of finished product					Physical characteristics			Storage time required to develop viscosity of 600 poises		
		Temp.	Time	Total solids	Fat	Honey sugars	Sucrose	Sugar ratio [b]	Reaction	Refractive index	Viscosity at 86° F after 1 day	60° F.[c]	70° F.[c]	86° F.
		° F.	*Min.*	%	%	%	%		*pH*	n^{25}_{D}	*Poises*	*Days*	*Days*	*Days*
1	Sugar	180	10	72.5	12.0	None	42.1	60.5	6.30	1.4623	83	265	131	44
2	Honey	180	10	71.1	12.4	39.8	None	57.9	6.00	1.4602	154	73	36	12
3	Sugar	240	0.5	72.6	12.0	None	42.2	60.7	6.21	1.4636	17	1,200	610	196
4	Honey	240	0.5	72.0	12.5	40.3	None	59.0	6.00	1.4623	17	465	232	76

[a] Each batch was made with 100 pounds of milk and 22.6 pounds of honey or 18 pounds of sugar. The honey contained 15.67 percent moisture and was a blend of 2 parts sweet clover and 1 part California white sage. The reaction of the honey was pH 3.8 and it contained the equivalent of 13.1 ml. of normal acid per kilogram. Before the honey was added to the forewarmed milk it was nearly neutralized by the addition in solution of 2.312 grams of $Na_3PO_4 . 12\ H_2O$ per kilogram of honey. The honey was then pasteurized at 170° for 20 minutes.

[b] Sugar ratio $= \frac{\text{sugar}}{\text{sugar} + \text{water}} \times 100$. [c] Calculated values.

of the honey before it was added to the concentrated milk appeared to be unnecessary for the milks used in this experiment. Partial neutralization of the honey might be helpful in the case of milks of unusually low heat-stability. However, stabilization of milk samples 1-6 in Table 2, with the usual disodium phosphate, was a more effective method of adjusting the heat stability than by neutralizing the honey.

The storage stability of evaporated milks that contained honey was excellent, except for changes in color. The color of the samples that contained honey darkened more rapidly than did that of the controls.

Since the proportion of honey to milk solids was much lower in the evaporated than in the sweetened condensed samples, there was less honey flavor in the evaporated milks. Some of the heat sensitive components of the honey flavor may have been lost in the sterilization treatment to which the evaporated milks were subjected.

Viscosity of the milk and size of the fat globules largely determine the degree of separation that will occur in evaporated milks held in storage at constant temperature. Samples shown in Table 2 that contained honey were of a higher viscosity than the controls (no honey) and showed less fat separation during storage. Milks 5 and 6 (Table 2) containing the quantity of milk solids normal in evaporated milk plus 8 percent honey had a very heavy body and these were remarkably stable during storage.

These experiments on honey-flavored evaporated milk suggest the possibility of preparing a sterile honey-flavored beverage milk having somewhat lower milk solids content than evaporated milk. Such a product might be patterned after a recently described caramel-flavored sterilized milk which contained about 22 percent total solids *(14)*.

Dried Honey-Milk Mixtures

Honey technologists have long recognized that a dehydrated honey would be useful in food manufacure. A moisture-free honey is especially adapted to the preparation of packaged dry mixes and to the production of confections. The heat treatment required to boil off undesired water in candy manufacture is injurious to delicate honey flavors. The preparation of a satisfactory dried honey has thus far been found impossible because of the high levulose content of honey. Accordingly, part of the work of this project was directed toward production of a dried honey-milk mixture. Whole milk was used in some of the experiments and with it products of excellent flavor were produced. But the whole milk-honey mixtures have the same package requirements as dried whole milk. Gas packing is needed to retard rapid development of a tallowy flavor. Since food manufacturers can find convenient sources of milk fat, emphasis was placed on the development of dried honey-skim milk mixtures.

Different ratios of honey and skim milk were spray dried in a Gray-Jenson type unit having a 9-foot-diameter drying cone. Results of some typical experiments are presented in Table 3. Optimum conditions were obtained when the honey-skim milk solids ratio was not greater than 40:60 and when the solids content of the sprayed mixture did not exceed 40 percent. With the experimental drying equipment that was available, it was not possible to dry satisfactorily a mixture of equal parts of honey and skim milk solids.

TABLE 3

The Effect of Variations in the Solids Content of the Sprayed Mixture and the Temperature of the Drying Air Upon the Drying Properties of Honey-skim Milk Mixtures [b]

Sample No.	Solids content of skim milk	Solids content of mixture when sprayed	Honey solids-skim milk solids ratio	Drying air temperatures		Properties of powder
				In	Out	
	%	%		° F.	° F.	
1	28	41.9	50:50	260	190	Candied mass, sticky
2	41	55.1	50:50	290	190	Burned, brown
3	36	46.7	40:60	255	195	Sticky, lumpy
4	36	43.4	30:70	250	195	Sticky, few lumps
5	30	34.5	20:80	265	190	Smooth, dry powder
6	30	37.1	30:70	265	190	Smooth, dry powder
7	30	40.4	40:60	265	190	Dry, slight caking
8	24	35.1	40:60	250	190	Smooth, dry, satisfactory
9	20	32.3	50:50	260	195	Sticky, lumpy mass

[b] The skim milk was forewarmed at 185° F. for 15 minutes before it was concentrated. The honey, which contained 16 percent moisture, was pasteurized at 160° for 10 minutes and then mixed with the concentrated skim milk. The honey-skim milk mixture was sprayed (at 135° F. and 2,000 lbs. pressure) through a 0.025-inch nozzle at the rate of about 600 lbs. per hour.

A description of the method of spray drying the mixtures is given in a footnote to Table 3. The composition of three experimental powders is given in Table 4. The spray dried powders were highly hygroscopic because of the presence of lactose, dextrose, and levulose in amorphous condition. A more stable powder could be produced, where facilities are available, by drying to about 12 percent moisture and passing the powder through a conditioning unit or rotary tunnel drier where most of the lactose could crystallize. Another possibility would be

TABLE 2

Characteristics of Evaporated Milks Made With and Without Honey [a]

Sample No.	Reaction of honey	Composition of finished product				Physical characteristics of finished product						
		Total solids	Milk solids not fat	Fat	Honey solids	Heat stability at 240° F.	Reaction after sterilization	Viscosity at 86° F. during storage at 86° F.			Fat separation at 86° F.	
								1 day	100 days	1 year	100 days	1 year
	pH	%	%	%	%	*Min.*	*pH*	*c.p.*	*c.p.*	*c.p.*		
1	.....	26.0	18.0	8.0	0	23	6.08	33	15	41	Moderate	Heavy
2	4.31	28.0	18.0	8.0	2	18	6.02	69	21	37	Slight	Moderate
3	4.31	30.0	18.0	8.0	4	16	5.99	124	43	62	None	Light
4	4.31	32.0	18.0	8.0	6	14	5.97	276	158	201	None	Slight
5	4.31	34.0	18.0	8.0	8	13	5.90	352	330	315	None	None
6	5.35	34.0	18.0	8.0	8	14	5.88	242	220	242	None	None
7	.....	26.4	18.3	8.1	0	35	6.18	25	14	32	Slight	Heavy
8	3.66	32.0	16.6	7.4	8	33	6.09	49	37	45	Slight	Light
9	5.79	32.0	16.6	7.4	8	33	6.09	26	20	18	Slight	Moderate
10	4.31	32.0	16.6	7.4	8	33	6.03	53	34	45	Slight	Light
11	5.35	32.0	16.6	7.4	8	33	6.04	41	25	25	Slight	Moderate

[a] Samples 1-6 were prepared in April from the same milk and tupelo honey. Samples 7-11 were prepared in May from another milk. Samples 8 and 9 contained fireweed honey, while samples 10 and 11 were made with the tupelo honey. The honeys used in samples 6, 9, 10, and 11 were neutralized to the indicated reaction. All honey samples were pasteurized and added to the milks after forewarming. Each batch of milk was forewarmed to 203° F. for 10 minutes before concentration, homogenized at 2,500 pounds pressure after concentration, and sterilized in cans at 240° 15 minutes. Viscosities greater than 100 c.p. indicate formation of a "liver" or gel structure during sterilization. Samples 1-6 were heat stabilized by the addition of 20 ounces of Na_2HPO_4 per 1,000 pounds of evaporated milk.

TABLE 4

Composition of Spray-Dried Milk and Honey Powders (In Part Calculated)

Composition	From skim milk		From whole milk
	Product I	Product II	Product III
	%	%	%
Moisture	3.2	1.6	2.5
Total solids	96.8	98.4	97.5
From honey	19.4	41.3	19.5
From milk	77.4	57.1	78.0
Butterfat	0.8	0.6	20.0
Milk proteins	28.6	21.3	21.4
Sugars, total	60.3	68.8	50.4
Lactose (milk sugar)	41.7	29.7	31.6
Levulose	9.2	20.5	9.3
Dextrose	8.9	16.7	9.0
Sucrose	0.5	1.9	0.5
Ash (mineral matter)	6.4 [1]	4.7	5.0 [1]
Undetermined	0.7	3.0	0.7
pH value, before drying	6.2	6.1	6.7
Sweetening effect [2]	31.0	55.0	29.0

[1] Includes calcium carbonate added to the honey.

[2] Calculated sweetening effect of the total sugars in terms of pounds of sucrose (ordinary sugar) per 100 pounds of product.

to prepare a highly concentrated (about 60 percent total solids) honey-sweetened condensed skim milk, allow the lactose to crystallize, and then spray the mixture in a centrifugal spray unit. Furthermore, a powder with a higher ratio of honey to skim milk might be obtained by using one of the above modifications.

Table 5 shows the equilibrium moisture content at several relative humidities for a spray dried honey-skim milk of 42.5:57.5 honey solids-milk solids ratio, and 0.96 percent moisture content as made. The data were determined by the static method used for dried skim milk by Supplee *(11)* and Henry, Kon, Lea, and White *(3)*. Stokes and Robinson's data *(10)* were used to relate relative humidity and sulfuric acid concentration. The equilibrium values in Table 5 are those at 68 days, at which time the rate of change averaged less than 0.02 percent moisture per week.

It appears from the data in Table 5 that the product is not quite as hygroscopic as dried skim milk at relative humidities below 30 percent, but at humidities above this value the honey-skim milk powder is more hygroscopic.

The maximum moisture contents and the equilibrium values are identical up to 30 percent R. H. (5.19 percent H_2O); above this point a decrease in moisture to equilibrium was noted after an initial rapid absorption as shown in the table. This was accompanied by caking of the powder, which is ascribed for dried skim milk by Troy and Sharp *(13)* to crystallization of lactose hydrate. This "over-shooting" has been reported by many observers in the past. No such decrease in moisture content was noted for the 30 percent R. H. powder, although caking was evident. To insure satisfactory storage stability dried honey-skim milk should be made and held under such conditions that the moisture content of the product does not exceed 3.5-4 percent.

TABLE 5

The Effect of Relative Humidity Upon Moisture Content of a Spray-Dried Honey-Skim Milk (Solids Ratio 42.5:57.5) at 25° C.[a]

Relative humidity	Moisture content [1]		Condition of powder
	Maximum	Equilibrium	
%	%	%	
6.0	1.02	1.02	Free-flowing
10.0	1.42	1.42	"
18.0	2.16	2.16	"
30.0	5.19	5.19	Caked
39.5	7.50	6.48	"
51.7	10.7 [m]	8.73	"
71.1	15.5 [m]	15.07	"
100.0	50.6 [n]	.....	.....

[a] For comparison, the equilibrium values given for spray-dried skim milk by others are: Henry et al. *(3)*: 41% RH-7.5% H_2O; 29% RH-5.0% H_2O; 17.5% RH-3.0% H_2O. Tamsma *(12)*: 50% RH-6.4% H_2O; 40% RH-6.7% H_2O; 30% RH-4.8% H_2O; 20% RH-3.5% H_2O. Davis *(2)*: 60% RH-8.25% H_2O; 40% RH-7.10% H_2O. For honey, Lothrop *(6)* reports: 70% RH-26.0% H_2O; 60% RH-18.4% H_2O; 50% RH-12.6% H_2O; and 30% RH-8.02% H_2O.

[1] Calculated on "as is" basis.

[m] Interpolated.

[n] Discarded at 42 days, molded.

A new method for the preparation of a dry honey-skim milk mixture was developed as a result of the experimental work described above. The honey was mixed with spray dried skim milk that contained amorphous lactose. The non-crystalline lactose as well as the uncrystallized dextrose in the honey, being present in highly supersaturated condition, crystallized. In crystallizing, each molecule of these sugars combined with one molecule of water of crystallization furnished by the honey. As a result of the reduction in free water content, the mixture lost its viscous consistency as well as some of its hygroscopic qualities and acquired a granulated texture. The crystallized product which usually contained less than 10 percent moisture could be further dried on trays or in a rotary tunnel drier.

During experiments with the "dry mix" method, the ratio of honey solids to milk solids was varied but best results were obtained when this ratio was 40:60. No more honey than that needed to produce a 50:50 mixture could be used. Mixing was done at room temperature in a kettle equipped with a double action, scraper-agitator. The honey was drizzled into the powder in fine streams and intimately mixed so that large droplets of honey would not become isolated and surrounded by a powder coating.

This "dry mix" method would be easy to carry out with simple equipment. The raw materials—honey and dried skim milk—could be assembled at any convenient location. Large quantities of the powder could be prepared for storage or sale, or small lots could be made specially for use in specific bakery or candy products.

The honey flavor of the honey-dried skim milk mixtures persisted much longer than did that of the spray dried products. After 4 to 6 months of storage at room temperature, the spray dried mixtures were weak in honey flavor and a stale powder flavor began to appear. After 10 months in storage, the honey-dried skim milk mixtures (dried to 2 percent moisture at the time of manufacture) still showed an attractive honey flavor and only a slight stale milk flavor. It was necessary to package all samples in sealed cans to prevent moisture pickup by the levulose of the honey. Some darkening in color was noticed in all the dry mixtures held at room temperature but this darkening was not considered objectionable until the samples were held at least one year.

SUMMARY

1. Concentrated milk and honey products with good storage stability can be prepared for use in infant or special diets and also for use as a highly condensed or dried source of milk and honey in the manufacture of dry mixes, confections, bakery goods, and other foods.

2. Sweetened condensed milks made with honey in place of sugar were held for 6 months at 70° F. (21° C.)

before objectionable thickening occurred. It was necessary to forewarm the milk, before evaporation, to about 240° F. (116° C.) for ½ minute to retard thickening in storage.

3. Evaporated milk fortified with 8 percent honey solids had adequate heat stability to withstand sterilization. The viscosity of the honey-evaporated milk was greater than the viscosity of normal evaporated milk. Since high viscosity retards phase separation, it is desirable in this product. Except for a darkening in color, the honey-evaporated milk withstood storage for 1 year at 86° F. (30° C.) better than the samples without honey.

4. Dried honey-skim milk mixtures with 40 parts of honey solids to 60 parts of non-fat milk solids were successfully prepared by two different methods: (1) Spray drying, and (2) mechanical mixing of the honey and dried skim milk. Both processes produced excellent products but the mechanically dry-mixed powder maintained a good honey flavor during storage longer than the spray dried product. Both powders were hygroscopic and darkened somewhat during storage.

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Methodology for Sensory Evaluation of Imitation Peppers[a]

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A method of procedure is described for the evaluation of imitation peppers by comparison with a natural pepper control. Five sensory tests for estimating similarity at successive levels are described and their utility demonstrated. Results of consumer preference tests are reported which call into question the basic importance of pepper to the flavor of foods.

During World War II, when black pepper was not easily available, imitations appeared and found a limited market. Since the war a continued scarcity of natural pepper has kept the interest in such products active. The quality of imitation peppers has been erratic and sales have been limited. However, because of the drive for national self-sufficiency as well as scarcity and high prices, imitation peppers are increasing rather than decreasing in importance and methods of evaluating developments in the field are needed.

The present paper is concerned with the development of sensory evaluation methods only, and not with the physical and chemical aspects. The nature and complexity of the problem militated against the attainment of precise solutions. Techniques adequate for obtaining practical information are described, however, it is recognized that considerable refinement is possible.

Experimentally useful criteria had to be generated from incomplete knowledge of the true role of pepper in food and some decisions were necessarily arbitrary. Since pepper is used primarily not for its own flavor but

[a] Presented at the Tenth Annual Meeting of the IFT, Chicago, Illinois, May 24, 1950. This paper reports research undertaken at the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned number 316 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or endorsement of the Department of the Army.

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for its effects in combination with foods, any attempt to judge pepper, as such, does not come to grips with the real problem. It would seem logical to require only that imitations replace natural pepper in foods without lowering acceptability. But experimental difficulties would beset such a program, since pepper may be used in hundreds of different foods or recipes and one would never know in how many an imitation should be tested before approval. This criterion of simple suitability encounters another difficulty. Many imitations have no proven effect on the acceptability of foods, yet have failed on the consumer market. This happened because the consumer did not judge them with regard to their possible use in foods. Imitations were rejected because under optimal sensory conditions they did not match his idea of pepper. This suggests another extreme criterion of a practical sensory identity with genuine pepper. Obviously, any imitation which met this criterion would be highly satisfactory but at the present time it is impractical in that it seems impossible of attainment. The present investigation adopted a plan of evaluation in successive stages, using criteria between these two extremes.

EXPERIMENTAL

Flavor Carriers. Pepper and other spices have been judged by the method of direct stimulation by mouth *(1)*. However, pepper is a strong stimulant and direct exposure to it creates a psychological disturbance that prejudices any skilled act. Pepper at full strength arouses sensations of both pain and heat as well as those of true flavor, whereas in normal usage with extreme dilution the former are reduced below their conscious thresholds even though they may contribute to the total effect. In the present investigation the observers' strong negative attitudes when subjected to pepper at high intensity constituted a controlling factor that required the use of flavor carriers.

A number of foods, including tomato juice, hamburger, soup stock, white sauce, scrambled eggs, and mashed potatoes were evaluated for suitability as flavor carriers on the basis of the ease with which differences caused by variation in quality and quantity of pepper could be detected in them and also for the stability of observers' quality judgments in replicate testing of a group of imitation peppers. None of the foods showed any definite superiority and tomato juice was selected since it permitted better physical control during testing.

The best discrimination in taste tests was obtained using distilled water as a diluent. Water infusions were prepared by a standard series of operations representing extraction conditions more thorough than those encountered in the mouth during eating, but certainly not as severe as those which pepper undergoes during preparation of most cooked foods. One gram of pepper or imitation was added to one liter of distilled water at 36.7° C. (98° F.). This mixture was allowed to stand for one minute and was then filtered rapidly. Lesser concentrations were obtained by dilution. Infusions were made fresh each day. Dry pepper was used for odor tests, one gram of the ground material being spread out on the bottom of a 300 ml. Erlenmeyer flask fitted with a ground glass stopper. Anticipating an accusation of inconsistency in that this represents testing without dilution, it is pointed out that in all odor testing air is the effective diluent. The dilution is great; unfortunately it is also variable. Pepper was added to the tomato juice in the proportion of 0.04 g. per 100 ml. The level was arbitrarily selected since pepper is customarily added "to taste." At this level the flavor of genuine pepper was definitely perceptible to most people yet few considered it too strong.

Observers. Observers of two different types were used. Preference testing was done by people who were as representative of the unselected consumer as it was possible to obtain. These observers were called randomly from among a large available group, excluding anyone with either knowledge of the present problem or technical knowledge of spice quality, and all persons on the difference testing panel.

A selected panel of observers was used for all difference tests. Starting with a group of 88 persons, selection of 25 persons of superior skill in detecting quality and intensity differences between peppers was accomplished through elimination by successive series of the difference tests which are described later. Thus selection was on the basis of consistently demonstrated skill in the type of tests that were used.

Genuine Pepper Control. A good typical black pepper supplied by a major spice company served as a constant reference point in all tests. A 50-lb. lot of this freshly ground pepper was packed in air-tight 1-lb. cans for storage. New cans were opened as needed and after opening the pepper was kept in tightly closed glass jars. Difference tests showed that there was no loss in strength throughout the period of the experiment.

Test Methods. The tests included the five approaches which are briefly described below. Of these, the dual standard odor test and the triangle test have been described in detail in a previous article *(2)*.

1. **Dual standard odor test.** Two pairs of samples, each consisting of a control pepper and a variant being tested are presented in Erlenmeyer flasks covered with paper in order to hide possible differences in appearance. The observer first studies a pair which is plainly identified, being allowed to sniff one and then the other until he feels that he has formed a concept of the difference. Then he attempts to identify the samples in the unmarked second pair. Each observer gives two judgments at a session.

2. **Imitation odor identification test.** The observer is presented with a single pair of unidentified samples in the covered flasks, one containing control pepper and the other the variant, and is instructed: "One of these is genuine pepper; the other an imitation which will be more or less like the genuine pepper. Identify the imitation." He is required to guess if he is not sure. Two judgments are given at an experimental session.

3. **Triangle test in water infusion.** The standard water infusions are diluted using 3 parts of the stock infusion to 7 parts of distilled water. Thresholds for true pepper flavor were established for the panel members and this concentration was selected as being well above the threshold of the least sensitive panel member yet not high enough to cause distress. Samples of approximately 20 ml. are presented at room temperature in 1-oz. glasses. Following a "warm-up," which is a sample of the control, and a subsequent distilled water rinse, three coded samples, two controls and a variant, are presented simultaneously and the observer is asked to identify the variant. The observer gives a second judgment on a second set of samples after a water rinse.

4. **Triangle test in tomato juice.** Samples are prepared by adding control pepper and variant to unseasoned tomato juice at the concentration of 0.04 g. per 100 ml. Any difference in appearance is cancelled by adding an excess of neutral pepper-base to both lots until they appear equal. Temperature, size of sample, and test procedure are the same as for the water infusion test.

5. **Paired comparison preference test.** Samples of tomato juice are prepared as for the triangle test; they are 30 ml. in quantity and are presented at room temperature. Following a "warm-up" and rinse, two coded samples comprising the pair are presented simultaneously. The question is asked "Which do you prefer?" A second pair is presented after a rinse.

RESULTS AND DISCUSSION

The methods described here have been used regularly to evaluate imitation peppers and ingredients proposed for use in their formulation. Not all samples are subjected to all five tests since in many cases sufficent information can be obtained by use of only one or two of them.

Data are presented in Table 1 for nine samples that were subjected to the full battery of tests. In the triangle tests, 33⅓ percent correct responses would be

TABLE 1

Genuine and Imitation Peppers Compared to Genuine Pepper Control

Sample		Dual Standard Odor Test			Imitation Odor Identification Test			Triangle Test in Water Infusion			Triangle Test in Tomato Juice			Preference Test in Tomato Juice		
		N	Percent Correct [d]	Sig.[e]	N	Percent Correct [df]	Sig.[e]	N	Percent Correct [e]	Sig.[e]	N	Percent Correct [e]	Sig.[e]	N	Percent Preferring Sample [d]	Sig.[e]
Genuine Peppers	A	20	90.0	***	36	69.4	**	40	37.5	0	40	37.5	0	....	....	....
	B	40	75.0	***	40	35.0	**	40	32.5	0	40	40.0	0	....	....	....
	C	40	72.5	***	40	55.0	0	40	42.5	0	40	37.5	0	....	....	....
Pepper Extenders	D	40	80.0	***	30	76.7	***	40	40.0	0	38	31.6	0	50	52.5	0
	E	38	86.8	***	40	87.5	***	68	38.2	0	40	30.0	0	80	55.0	0
Commercial Imitation Peppers	F	20	100.0	***	40	87.5	***	40	70.0	***	40	70.0	***	40	45.0	0
	G	20	100.0	***	40	80.0	***	40	57.5	***	40	42.5	0	40	52.5	0
Experimental Imitation Peppers	H	40	90.0	***	20	90.0	***	40	67.5	***	40	55.0	***	111	56.7	*
	I	20	95.0	***	21	95.2	***	40	67.5	***	50	50.0	**	75	54.7	0

[e] Code: *** significant at the 1% level
** significant at the 5% level
* significant at the 10% level
0 not significant

[d] 50% correct expected by chance
[e] 33⅓% correct expected by chance
[f] Identification of the non-control pepper as the imitation called "correct"

expected by chance alone if there were no difference between control and sample; 50 percent correct responses or preference choices for the sample would be expected on the other three tests. Observed percentages deviating from these chance percentages with significance at the 1, 5, and 10 percent levels are shown. In reporting results of the odor identification tests on genuine peppers, "correctness" is defined as selection of the variant.

The testing of samples A, B, and C, brands of genuine pepper selected at random, was a necessary rationalization of the procedure which used a single lot of pepper as a control. It defined the relationship between various natural black peppers. All three samples were significantly different from the control pepper on the dual standard odor test. In the odor identification test, which reflects interpretation as well as simple detection of difference, discrimination was less precise as shown by the smaller percentages found correct. Sample A was interpreted as being "imitation" significantly more often than the control. Sample C showed no difference, and sample B was called "imitation" even less often than the control. Results on both triangle tests show no variation from the chance pattern and therefore the preference test was not tried.

Samples D and E were preparations available commercially, consisting of pepper extractives adsorbed on a salt base, and should be considered as pepper extenders. The dual standard odor test revealed differences from the control of about the same order as with the genuine peppers. In the identification test, however, the preparations were consistently judged as "imitation." Since no difference was shown by either triangle test the "no difference" result on the preference test would be expected.

Samples F and G were commercial imitations which appeared on the consumer market during the war. Odor differences were marked, with perfect scores on the dual standard test and nearly as unanimous agreement on identification. Sample F showed the greatest difference on the taste tests of any of the samples, while Sample G dropped to the chance level on the tomato juice test. Note, however, that even Sample F was not inferior to the control on the basis of preference.

Samples H and I were two laboratory formulations which originally had seemed promising. They exhibited extreme difference from the control on both odor tests. The percentages found correct dropped in the water infusion triangle test and still more in the tomato juice test, even though all differences remained significant at either the 1 or 5 percent levels. In spite of such definite qualitative differences, there was but little discrimination on preference.

In Table 2 the results on all nine samples are brought together for purposes of comparison with only the significance of each test being shown. There is a definite order of sensitivity within the group of tests, ranging from the dual standard which showed all nine samples to be different from the control, to the preference test which found only one slight difference; also it is possible to place the samples in a definite order of similarity to the control pepper. Table 2 demonstrates that the two series can be presented simultaneously without a single

TABLE 2

Significance of Test Results: Imitation and Genuine Peppers vs. Genuine Pepper Control [g]

Test	Experimental Imitation Peppers		Commercial Imitation Peppers		Pepper Extenders		Genuine Peppers		
	H	I	F	G	D	E	A	B	C
Dual Standard Odor	***	***	***	***	***	***	***	***	***
Imitation Odor Identification	***	***	***	***	***	***	**	**	0
Triangle in Water Infusion	***	***	***	***	0	0	0	0	0
Triangle in Tomato Juice	***	**	***	0	0	0	0	0	0
Preference in Tomato Juice	*	0	0	0	0	0	....	....	....

[g] Codes as in Table 1.

inversion of either order, which means that the results on each sample agreed perfectly with the general trend of the data. An orderly system of measurement is thus implied, although the agreement depended also on there being an orderly series of flavor properties in the samples. That it actually so happened was, in large part, chance. Even so, the orderly nature of these results implies validity of the system of evaluation.

Considering the present stage of development in the field, it can hardly be required that all work on imitation peppers continue until identity with natural pepper is attained. For this reason a test which will predict the utility of an imitation that only partially meets the objective of identity is valuable. This was one consideration in the selection and development of the tests.

The odor tests on the dry pepper represent the situation in which a buyer of pepper is most likely to judge the imitation, i.e., by direct odor examination. The dual standard test sets optimum conditions and is too sensitive to represent practical evaluation. The odor identification test, at the next level of sensitivity, would give better prediction of whether an imitation were reasonably close to the customer's concept of natural pepper. The triangle test in water infusion has no analogue in practical use. It is designed to exhibit, under conditions made optimum for discrimination, those flavor properties which are effective when pepper is eaten in food. An imitation pepper which passed this test could be substituted for genuine pepper in any food without changing its flavor. The practicability of this test is shown by that it passed without question all three genuine peppers and also the two commercial preparations containing the pepper extractives. The inference is that it would not reject any imitation with a true pepper flavor.

The tomato juice triangle represents use in a typical food. It gives an estimate of the probability of the existence of a flavor variation that could carry through when blended with food flavors. A test comparable in purpose to this one could be set up using any one of many foods. Although our preliminary work on flavor carriers indicated that there would be little difference in sensitivity of the test with any of the foods tried, the list of flavor carriers tested is not all-inclusive. It seems certain that foods could be selected which would give either greater or lesser sensitivity.

The preference test in tomato juice should be the most meaningful of the whole series since it evaluates any flavor variations that may exist by that final practical criterion, consumer preference. Here the preference test failed to discriminate between samples, since even those imitations which were definitely different from the control pepper were preferentially equal to it. However, it is possible that an imitation may be considered at some time which could not meet this criterion; certainly the test must be used whenever a difference can be shown.

Is Pepper Essential to Flavor?

The question of the true role of pepper was a natural corollary to these results. If an imitiation pepper, quite different from the genuine material, is preferentially equal to it, how important is pepper itself to the flavor of foods?

To answer this question consumer preference tests were run in which foods seasoned normally with pepper were compared directly with the same foods without pepper. Seasoning levels of these foods were determined by usual recipes or by military specifications. The basic data were gathered by the same paired-comparison method used for the tomato juice preference test. The results obtained are given in Table 3. More data were obtained on some foods than on others since any test was extended when first results indicated a trend in either direction.

TABLE 3

Paired-Comparison Preference Tests of Foods With and Without Pepper

Food	Percent Pepper by Weight	N	Percent of Observers Preferring		Significance [1]
			Sample without Pepper	Sample with Pepper	
Cream of Tomato Soup	0.015	80	60.0	40.0	**
Tomato Juice	0.040	60	60.0	40.0	*
Corned Beef Hash [b]	0.038	80	57.5	42.5	0
Beef Stew [b]	0.021	39	53.8	46.2	0
Hamburger	0.220	60	48.3	51.7	0
Mashed Potato	0.040	40	47.5	52.5	0
Beef and Gravy [b]	0.045	80	45.0	55.0	0
Soup Stock	0.020	74	41.9	58.1	*
Pork Sausage	0.130	122	41.8	58.2	**
Vegetable Soup	0.010	80	33.8	66.2	***

[b] Canned ration items.
[1] Codes as in Table 1.

Only in the case of vegetable soup was it definitely established (1 percent level) that pepper improved flavor. There were two trends for the food containing pepper, also two trends against it, but in all four cases the variation from the chance percentage is not large. To test the hypothesis that this may have been due to the test method, which employed a number of small samples presented at one session, results on four of the foods were checked by a second method. The observer ate 2-ounce portions of each food but only one sample at a session, and rated each on a scale whose nine points ranged in successive categories from "dislike extremely" to "like extremely." This preference scaling device is used regularly in our laboratory and has been found to give reproducible results. Three canned ration items and pork sausage were tested using consumer observers. Mean ratings on the scale were almost identical for the canned meats with and without pepper. With pork sausage there was a very slight trend toward preference for the sample containing pepper, which agrees with results of the paired-comparison test.

These results are not conclusive but they strongly suggest that the traditional role of pepper has been overestimated and that many people would be content to use much less of it or none at all. There are two factors which qualify this tentative conclusion: (1) pepper was tested in only a few of the many ways in which it is used, and (2) testing was confined to one group of consumer-observers who can not be considered representative of all potential pepper-users. However, even if the conclusion can not claim universality, it constitutes a serious questioning of the importance of natural pepper to flavor. This is significant to the development of imitiation peppers because, if pepper itself is relatively unimportant in foods, then the task of developing suitable substitutes should be less imposing.

SUMMARY AND CONCLUSIONS

A battery of five tests was developed for the purpose of evaluating imitation peppers by comparison with a natural pepper control. They fall into a consistent order of sensitivity. The most sensitive, the dual-standard odor test with the dry peppers, revealed definite differences even between natural peppers and the control. The least sensitive, preference in tomato juice, showed but little difference between imitation and the control pepper. All tests with the exception of the triangle difference test in water infusion are analogues of practical evaluation situations. This series of tests will show relative values of imitation peppers; single tests can be selected for specific purposes.

Consumer preference tests showed that pepper does not improve the flavor of many foods in which pepper is normally used.

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